MACHINERY.

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THE BURSTING STRENGTH OF WOODEN PULLEYS.

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During the winter of 1902-3 a series of experiments was carried on in the laboratories of the Case School, Cleveland, Ohio, by Mr. E. G. Schick, a junior student, to determine the bursting speeds of various types of wooden pulleys such as are used on shafting. At the time it was expected that these experiments would be supplemented by others, but the pressure of other work prevented this. It seems best, therefore, to publish such results as we have, pending further tests.

Eight pulleys of three different makes were tested, Nos. 1 and 2 being made by one firm, Nos. 3, 4 and 8 by another, while Nos. 5, 6 and 7 were the product of a third factory.

The pulleys were four inches in width of rim and all were two feet in diameter, except No. 7, which had a diameter of twenty inches. The testing apparatus was the same as that used so extensively in bursting small flywheels and is shown in Fig. 1 with pulley No. 1 in position.

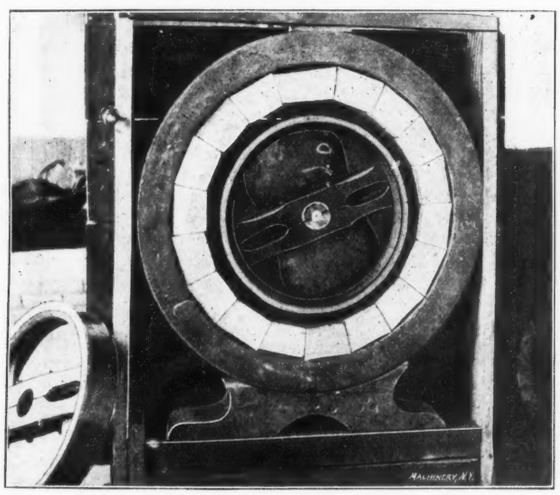


Fig. 1. Pulley No. 1 in place in the Testing Apparatus.

The pulleys were inclosed in a cast-steel ring four inches thick, having a lining of wooden blocks and covered at the sides with heavy oak planking. The shaft used was 1 and 7-16 inches in diameter and was driven by a Dow steam turbine of about twenty horse-power. The speed was measured by a pendulum tachometer, connected to the turbine shaft through belting and speed reducers. This arrangement was calibrated at a speed of 5,000 revolutions per minute and found to be correct.

The names of the manufacturers of the pulleys are not given, but the illustrations show the types of wheels represented. The pulleys were furnished by the makers and presumably were all of the best quality.

Pulleys Nos. 1 and 2 were alike, having the usual built up rim with two joints. The spokes consisted of two parallel bars either side of the split and clamped on the bushing at the hub by transverse bolts. (See Fig. 1.) The rim was reinforced on each side of the joints by wooden brackets or webs and these latter contributed to the failure of the rims.

Figs. 2 and 3 show the two pulleys after bursting. Instead of the rim failing at the middle of the unsupported span, as might have been expected, the failure occurred in both cases at the ends of the arms, the centrifugal force of the brackets before mentioned forcing the rim apart as shown in the illustrations. This force was so great as to rupture the arms in both pulleys.

In pulley No. 1 the arms were cross-grained but in the second pulley the centrifugal force ruptured and splintered sound, straight-grained lumber, as seen in Fig. 3. The only sign of failure at the 90-degree points was the disjointing of the rim caused by the opening outward at the ends of the arms. The bursting occurred at speeds of 2,200 and 2,250 revolutions per minute respectively, or linear speeds of 230 and 236 feet per second.

Pulleys Nos. 3 and 4 differed from the preceding in having arms which form a letter X inside the rim, as shown in Fig. 4. The pulleys were fastened to the shaft by clamp bolts through the arms and the rim joints were held together by malleable iron lugs fastened with one bolt each. The rims in both instances failed at the mortises where the arms were inserted, as may be seen in Fig. 9, which shows pulley No. 4 after bursting. The centrifugal force of the lugs and bolt probably helped to rupture the wheel at these points. The bursting speeds were 2,000 and 1,700 revolutions per minute, or 210 and 178 feet per second.

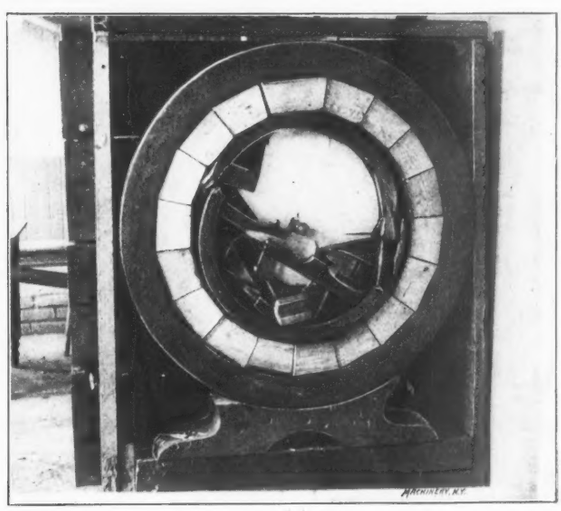


Fig. 2. Pulley No. 1 after Bursting.

Pulley No. 5 was similar to those numbered 1 and 2 having the same parallel arms either side of the split and the same reinforcements each side of the rim joint. As might have been expected, it failed in the same manner at the joints, as may be seen in Fig. 5, which shows its appearance after rupture. The weakening of the rim by the insertion of the arms, coupled with the additional centrifugal force due to the brackets, was the cause of the failure. This pulley, however,

PROF. C. H. BENJAMIN was born at Patten, Maine, in 1856. He served a machinist's apprenticeship at the shop of Benjamin and Allen, Oakland, Me., and took the course in mechanical engineering at the University of Maine, receiving the degree of M. E. He was employed by the McKay Sewing Machine Association, and later as assistant manager of the McKay and Bigelow Heeling Machine Association. He was appointed professor of mechanical engineering at the University of Maine, and later to the same position at the Case School of Applied Science, Cleveland, O., where he has since remained. Prof. Benjamin has become closely identified with the work of Case School and has impressed his individuality upon it to a marked degree. Among the interesting and original work that has been done under his direction is that of the experimental determination of the stresses in rotating bodies, such as flywheels, pulleys, etc. From 1900 to 1902 he was supervising engineer for the City of Cleveland and was placed in charge of the movement for smoke abatement in that city.—EDITOR.

proved to be considerably stronger than any before tested, the bursting speed being 2,450 revolutions per minute, or 257 feet per second.

Pulley No. 6 was made by the same firm as No. 5 and had a similar rim. The arms and hub, however, were made of pressed steel, as shown in the illustration, Fig. 6, which shows this pulley before rupture. The speed of bursting was just the same as in the preceding case, viz., 2,450 revolutions per minute, and the rupture occurred at one of the arms next one of the joints. (See Fig. 7.) The thin webs of the arms were inserted in the rim and steel pins driven through transversely to hold them. The wood outside these pins split and peeled off, carrying with it the rim on either side. The joint in the rim appeared to have nothing to do with the failure.

Pulley No. 7 was only 20 inches in diameter and was made

Fig. 3. Pulley No. 2, after Rupture.

Fig. 4. Pulley No. 3.

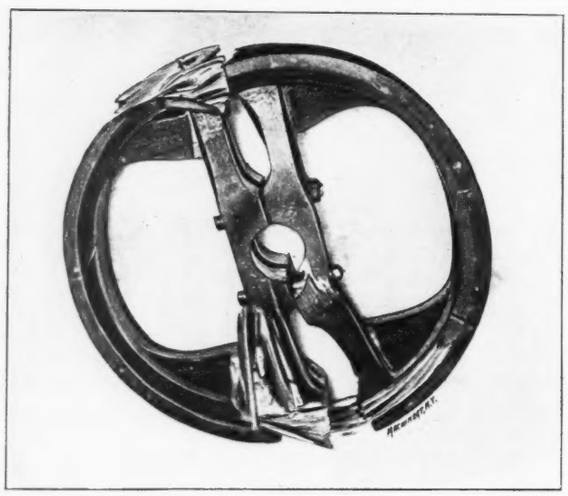


Fig. 5. Pulley No. 5, after Rupture.

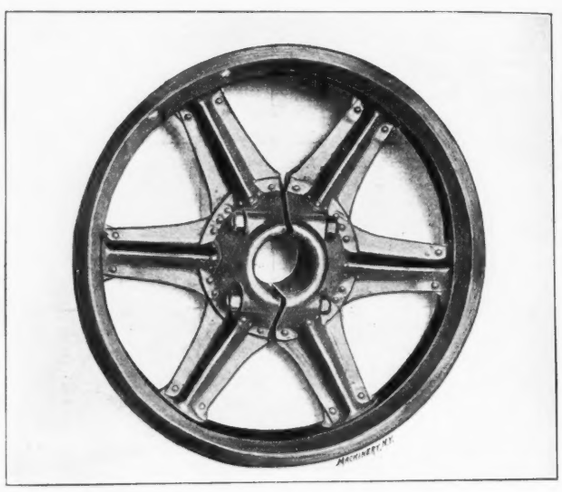


Fig. 6. Pulley No. 6, Steel Spokes.

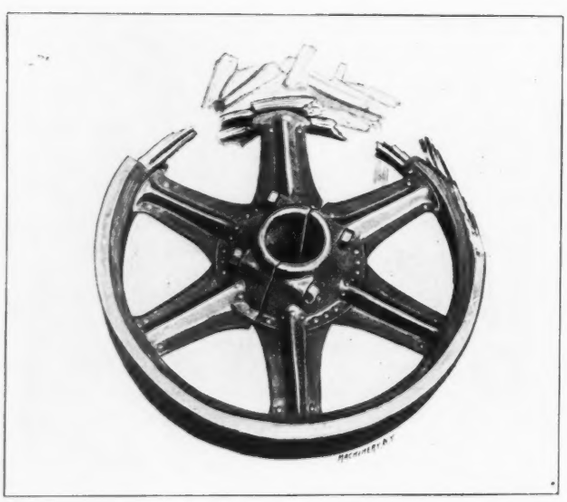


Fig. 7. Pulley No. 6, after Rupture.

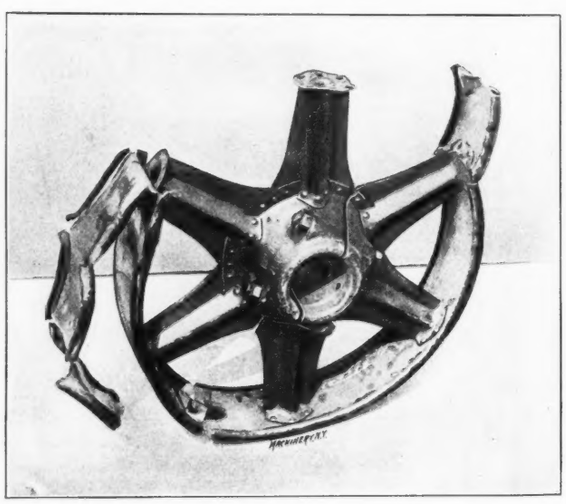


Fig. 8. Pulley No. 7, all Steel.

throughout of pressed steel. The arms and hub were the same as in the pulley last described but the rim, being of steel with rolled edges, was riveted to flanges on the ends of the arms as shown in Fig. 8, which represents this pulley as it appeared after bursting.

As may be clearly seen in the lower part of the figure each joint in the rim was secured by one bolt passing through sheet metal lugs riveted to inside of rim. The weakness of these lugs was the immediate cause of the failure. At a speed of 2,500 revolutions per minute the centrifugal force of the joint bolts caused the lugs to bend and the rim to open at the joints nearly one-half inch. The pulley finally failed at 2,550 revolutions per minute, or a rim speed of 223 feet per second, one

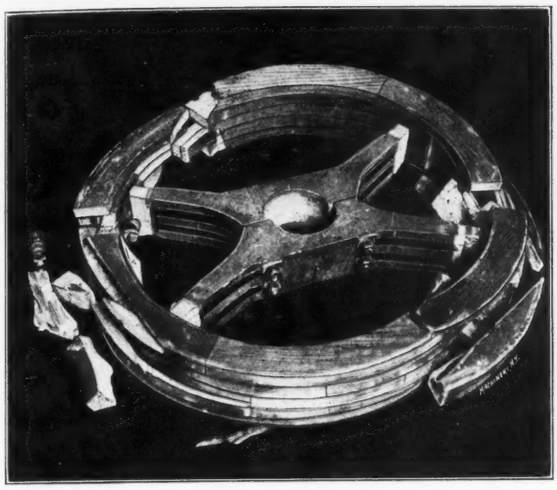


Fig. 9. Pulley No. 4, after Rupture.

of the bolts pulling out of the lug which held it and allowing the rim to open and bend back. See Fig. 8.

Pulley No. 8 was without arms, having a solid wooden web with cast-iron flanged hub. It was found impossible to burst this wheel with the power at command and the attempt was abandoned. A speed of 4,450 revolutions per minute, or a rim speed of 467 feet per second, was attained and this made no impression whatever upon the integrity of the rim.

The following table gives a resumé of the results of the experiments:

Table.

No.	Description.	Size.	R. P. M.	Feet per Sec.
1.	Wood Split	24″ × 4″	2,200	230
2.	Wood Split	24″ × 4″	2,250	236
3.	Wood Split	24″ × 4″	2,000	210
4.	Wood Split	24″ × 4″	1,700	178
5.	Wood Split	24″ × 4″	2,450	257
6.	Steel Arms	24″ × 4″	2,450	257
7.	All Steel	20″ × 4″	2,550	223
8.	Solid Web	24″ × 4″	4,450	467

(No. 8 was not broken.)

In comparing these pulleys with each other and with cast-iron pulleys of the same size it will be necessary to compute the centrifugal tension of wood as compared to that of iron or steel.

Let S = centrifugal tension (pounds per square inch).

Let v = velocity in feet per second.

Let w = weight of material per cubic inches.

Then it can be readily proved that for thin rims

$$S = \frac{12wv^2}{g}$$ if we neglect bending.

For iron and steel this reduces to $S = v^2/10$ approximately. The weight of dry hardwood, such as maple, is .027 pounds per cubic inch, or almost exactly one-tenth that of iron. We may then write for wood:

$$S = v^2/100.$$

(The material used in most of the pulleys tested was maple.) Assuming the tensile strengths as follows:

Soft Steel	60,000
Cast Iron	18,000
Wood	10,000

we have the values for linear velocity to produce rupture:

	Feet per Sec.
Soft Steel	775
Cast Iron	425
Wood	1,000

For pulleys two feet in diameter this corresponds to revolutions per minute of 740, 406 and 955 respectively.

Repeated tests on cast-iron pulleys and small flywheels have shown that a whole rim of this material will fail at speeds of from 350 to 420 feet per minute, depending upon the quality of the rim and the amount of bending between the arms. If the wood in a pulley rim were as homogeneous as the cast iron, speeds of from 800 to 1,000 feet per second could undoubtedly be attained.

It has been noticed that pulley No. 8 was uninjured by the speed of 467 feet per second. There are two causes for the failure of wooden pulleys at high speeds, the various joints in the rim and the mortises made to receive the arms. Furthermore, any attempt to strengthen the rim by wooden or metal braces and lugs usually does more harm than good on account of the centrifugal force of the added parts.

It should be said, however, to the credit of the wooden pulley, that with the exception of No. 4 the split pulleys tested ran at higher speeds before bursting than cast-iron wheels with rim joints.

The average bursting speed of thirteen cast-iron wheels of this same diameter and width having flanged rim joints, was exactly 200 feet per second, the lowest speed being 164 feet per second and the highest 230 feet per second. In other words, the average rim joint in such a wheel will stand only half the speed of the solid metal and is therefore only one-quarter as strong.

A four-foot split pulley of cast iron with flanges at joints burst at a speed of only 600 revolutions per minute, or about 125 feet per second. This pulley was of the usual type of split pulleys, having been cast in one piece with cored openings in the flanges at hub and rim. After the pulley was bored and turned the two halves had been broken apart with wedges. It will be seen that the wooden pulleys tested were nearly four times as strong as the last mentioned.

After all, the strength of a pulley rim, be it iron or steel, is a question of the efficiency of the joint. Had pulley No. 7 been properly fastened together at the joints in the rim, its bursting speed would have been at least half that of the solid metal, whereas it was only $223/775 = 0.288$ of that speed showing the efficiency of the joints to have been about one-twelfth.

The actual factor of safety in the pulleys tested, as they would be used in practice is ample. Assuming a maximum belt speed of 6,000 feet per minute, or 100 feet per second, the average speed factor is 2.27, giving a stress factor of over five. This is sufficient for machinery which is not subjected to shocks or reversals.

In designing pulleys of any material for high-speed service great care should be taken to avoid the use of balance weights or other added metal which will increase the centrifugal tension without a corresponding increase of strength.

* A four-foot cast-iron pulley with a whole rim was tested by the writer and burst at a speed of 1,100 revolutions per minute, or 230 feet per second. The cause of failure was a balance weight of 3½ pounds inside the rim. At the given speed the centrifugal force of this weight would be 2,760 pounds, and as it was located midway between the arms at the thinnest portion of the rim, it would enormously increase the stress at that point.

The deterioration of wooden rims on account of loosening of the joints from moisture or vibration has not been considered in this article as the pulleys tested were all new and fresh from the factory.

* * *

A gentleman who says he has been twenty years in the navy and is "getting on in years, so naturally has a tired feeling after hard work," contributes his experiences in an advertisement for the benefit of a certain cocoa firm as follows: "Whilst cruising the other day, one of the blades of our propeller came off, and I had to go and solder a spare one on. It was rather a long and tiring job, and I sincerely believe if it hadn't been for ———— cocoa, I should never have got through it." We should think not, indeed!—*Page's Magazine.*

* Trans. A. S. M. E., Vol. XXVI., 1905.

VARIABLE SPEED MECHANISMS.—4.

EXPANDING PULLEYS.

Of the large class of variable speed devices known as expanding pulleys, only a few of the recent patents have been chosen for the purpose of illustration in this series. A number of meritorious early patents have been ignored, it being thought best to show the later development of the art in this class.

Fig. 38 is a speed-changing pulley patented by August Harding, January 10, 1888, No. 376,150. The pulley really consists of two pulleys mounted on the same shaft and so constructed that the one expands as the other contracts. The pulleys are mounted in a swinging frame *A* and are connected by inde-

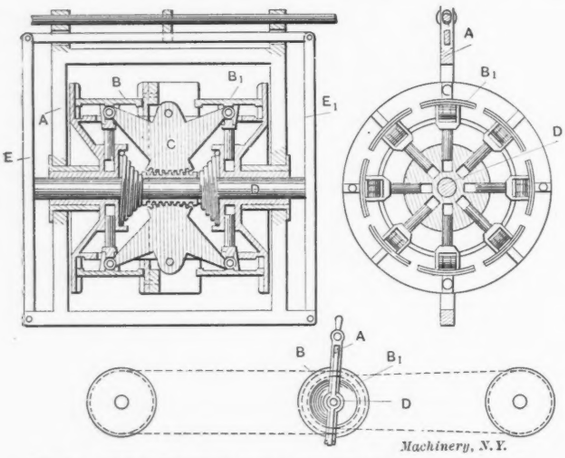


Fig. 38. August Harding's Patent, No. 376,150, January 10, 1888.

pendent belts to the driving and driven shafts. As one pulley, say *B*, is expanded the other pulley B_1 contracts and the swinging frame shifts to the left, thus maintaining equal tension on the two belts. The mechanism by which this reciprocal action of the two pulleys is obtained consists of a number of two-armed segments *C* pivoted centrally between the two pulleys. These segments are toothed on their inner faces and the teeth engage the grooved spool mounted on the shaft *D*, which is kept normally in a central position by coil springs. The shaft *D* is splined so that it turns with the pulley but is free to move longitudinally, being shifted

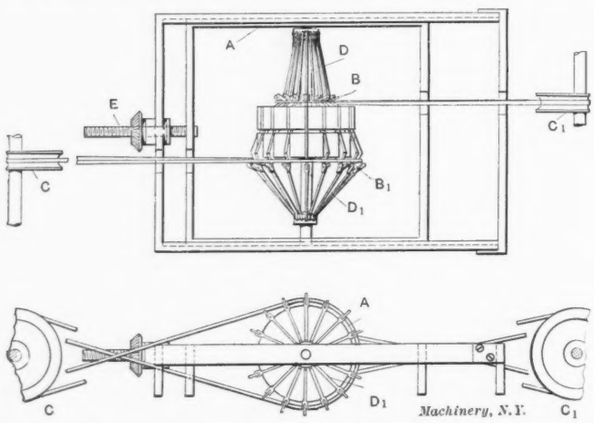


Fig. 39. Patent No. 580,327, granted J. McCraith, April 6, 1897.

by the levers *E* E_1. The longitudinal motion of the shaft rocks the segments on their pivots and expands one pulley while the other contracts.

Another speed-changing device very similar in principle to that patented by Mr. Harding is patent No. 580,327, by J. McCraith, April 6, 1897. This device, however, is only adapted to the use of round belts, the belt faces consisting of a series of notched levers *B* and B_1 pivoted at the centers and connected by a series of links *D* D_1 to sleeves sliding on the shaft. Frame *A* in which the expanding pulley is mounted, instead of having a swinging support, slides in another frame and its motion is controlled by a screw which is operated by a bevel gear and hand-wheel not shown. It is obvious that the movement of the frame *A* accomplishes a change of speed inasmuch as the pull of the belt being diminished on one side and being increased on the other, the levers will automatically rock on their pivots and increase the diameter of one member and decrease that of the other.

The variable speed mechanism shown in Fig. 40 was patented by Milton O. Reeves, April 26, 1898, No. 603,067. In

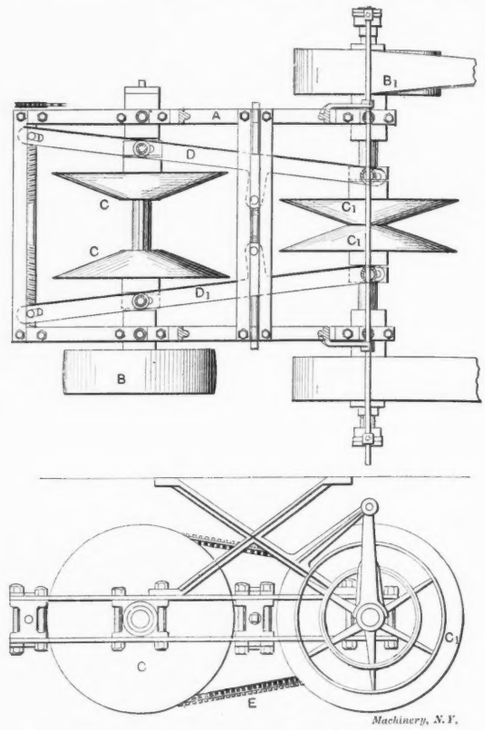


Fig. 40. Milton O. Reeves' Patent, No. 603,067, April 26, 1898.

this device two pairs of cones *C C* and C_1 C_1 are mounted on parallel shafts and are connected by levers *D* D_1 in such a way that, as one pair of cones approach each other, the other pair separate. A leather belt with wooden cross-pieces, having the ends tapered to conform to the tapers of the cones, is mounted on these cones. Motion is conveyed from one shaft to the other by a frictional contact of the cones against the ends of the wooden cross-pieces. To take care of the heavy end-thrust caused by this arrangement, the cones are pro-

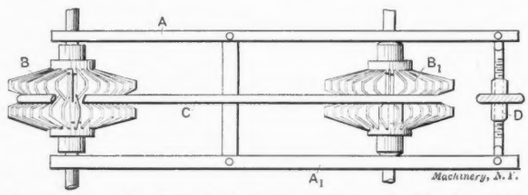


Fig. 41. Expanding Pulley Patented by C. E. Brooks, March 6, 1900, No. 644,702.

vided with ball thrust bearings. Two earlier patents were granted to Reeves, Nos. 583,402 and 588,354, for inventions covering the elementary features of this device.

The expanding pulley variable speed device patented by C. E. Brooks, March 6, 1900, No. 644,702, essentially consists of pulleys *B* B_1, frame *A*, belt *C* and the adjusting screw *D*, Fig. 41. The pulleys consist of intermeshing tapered leaves mounted on hubs and sliding longitudinally on supporting shafts. A V-groove is formed between the intermeshing leaves on each pulley, which, of course, expands and contracts with the longitudinal movement of the separable hubs. This movement is controlled by means of a right- and left-hand nut *D* which rocks the members *A* A_1 of the frame upon their pivots, causing the hubs of one pulley to approach, thus increasing the diameter of the V. The pull of the belt decreases the diameter of the V in the opposite pulley, thus keeping the hubs against the sides of the frame members *A* A_1.

The device shown in Fig. 42, patented by C. A. Gourgoulin

and A. H. Croizier, June 26, 1900, No. 652,541, is a reversing and speed-changing gear but the reversing feature is incidental and forms no essential part of the speed-changing mechanism. This latter consists of two pairs of conical pulleys A A_1, which are made with alternate sections of their inner faces cut out so that the inner face contour of one cone may enter that of the other, and *vice versa*, as the two are

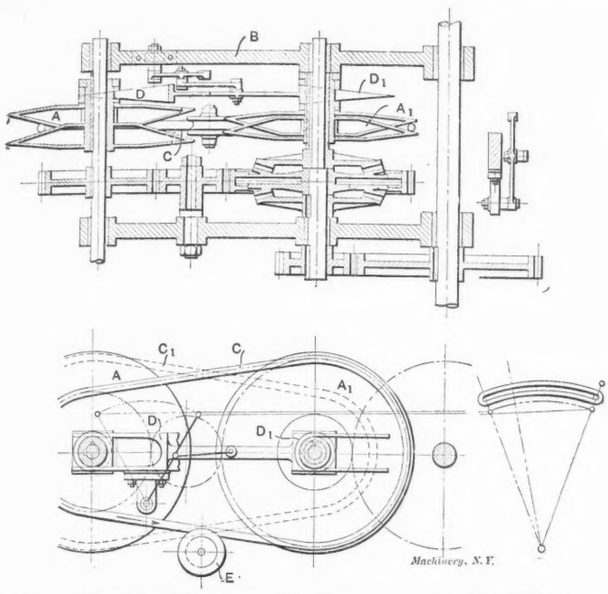


Fig. 42. Patent No. 652,541, granted to C. A. Gourgoulin and A. H. Croizier, June 26, 1900.

approached. Approach, of course, increases the diameter of the V-groove between them and the contrary action of the other pulley decreases this diameter. This movement is made in unison by means of two wedges D D_1, which are connected by a short rod. To this rod is pivoted a link which is connected to a hand lever not shown. The pulley E appears to have no necessary function except that it may be used as a tightener when the round belt stretches with use.

Fig. 43 is made from the drawing accompanying patent specification No. 658,655, granted to Ernst Lang, September 25, 1900. In this invention the pulley face segments B on which the belt is carried, are pivoted nearer the peripheries

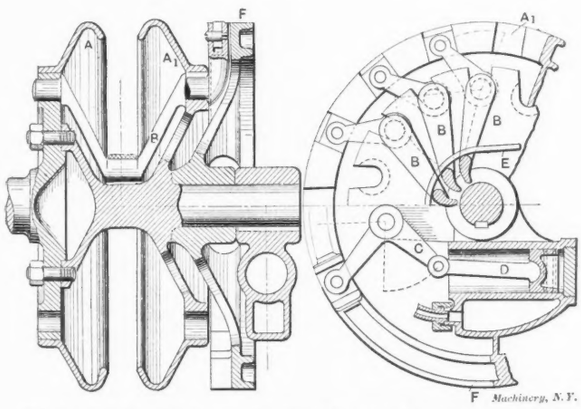


Fig. 43. Ernst Lang's Patent, No. 658,655, granted September 25, 1900.

of A A_1. To the outer end of these rocking pieces are short cranks, all connected to a ring F, which is mounted concentric with the shaft. This ring is operated by fluid pressure in the cylinder D. The shape of the members B in the part in contact with the belt E is such that rounded surfaces are presented to the inner sides of the belt in all positions that they may be placed by the action of the piston in cylinder D.

The apparatus, Fig. 44, for transmitting motion at variable speed, patented by A. Wache and A. Krieger, November 19, 1901, No. 687,090, consists of expanding pulleys having rims made on the "lazy tongs" or pantagraph principle, thus giving the belt a more or less continuous surface for operation. The rims are expanded and contracted by longitudinal movement of the sleeves mounted on their shafts and controlled by B, as shown in one view, or D, in the other, the actions being the same in each case. The inner end of the sleeves is grooved and engages the toothed ends of rocking levers E E_1. These levers are slotted and the slots engage pins on the inner side of the bars of the rims. As these levers are shifted inward, they carry the pulley rim along. The connection between

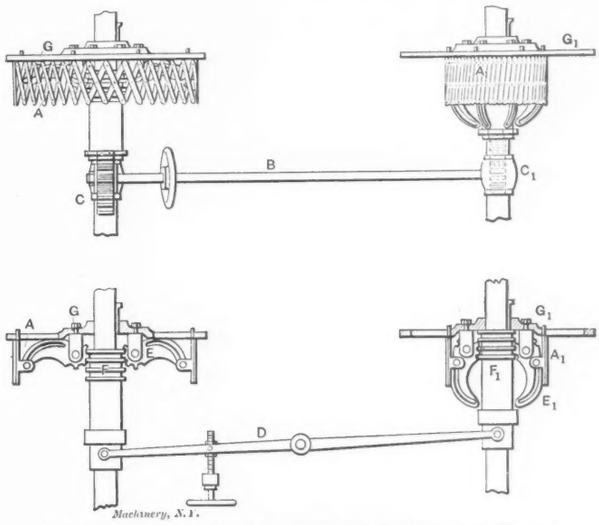


Fig. 44. Patent No. 687,090, granted to A. Wache and A. Krieger, November 19, 1900.

the two pulleys is such, of course, that the action is simultaneous, one pulley expanding as the other contracts. Disks G G_1 are provided with slots to guide and sustain the flexible rims against lateral displacement.

Patent No. 687,546, shown in Fig. 45, was granted to A. Sinclair, November 26, 1901. In this invention there are two pairs of opposing cones mounted on parallel shafts, each cone having narrow slots in which are loosely-fitted movable strips C C_1. The angle of the cones is so chosen that longi-

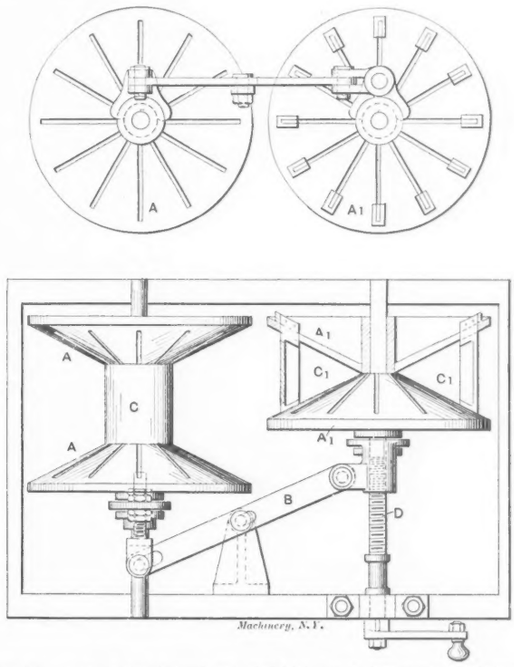


Fig. 45. A. Sinclair's Patent, No. 687,546, granted November 26, 1901.

tudinal movement of one cone toward the other forces the strips outward, thus expanding the belt diameter. This movement is effected co-ordinately by means of lever B, connecting each pair of cones. The lever is operated by the screw D, situated above the shaft on the right. It will be observed that since only one cone of each pair is given longitudinal

movement, the effect is to decrease the available belt width, making it only about one-half of the full length of the strips $C\ C_1$.

Expanding pulleys in general present broken surfaces to support the belt, but the invention of A. G. S. Lyford, April 9, 1901, No. 671,895, is designed to overcome this defect, the segments of the pulley faces being made to overlap as they contract or expand and thus preserve an unbroken contour. The pulleys $B\ B_1$, Fig. 46, are mounted in a frame A and the

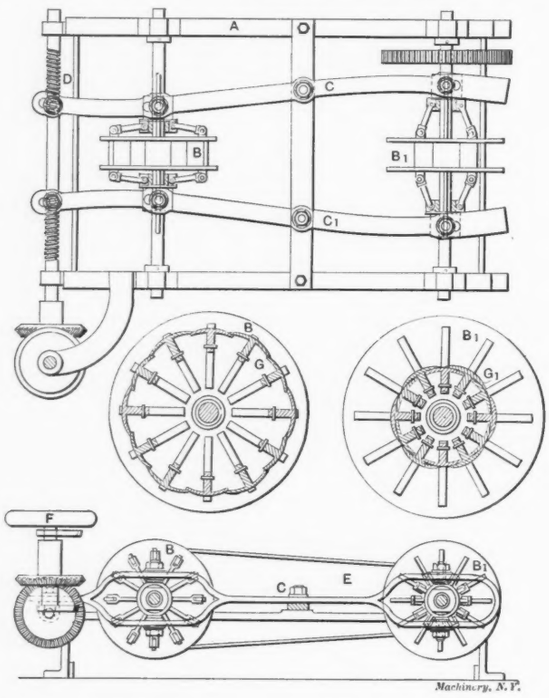


Fig. 46. Patent No. 671,895, granted to A. G. S. Lyford, April 9, 1901.

segment portions, which slide in radial slots, are connected by links with collars on the shafts, which, in turn, are connected to levers $C\ C_1$ pivoted in their centers. These levers are operated by the right- and left-hand screw D, thus giving co-ordinate motion to both sets of pulley segments, so that one expands as the other contracts. The cross-sectional views shown at $G\ G_1$ illustrate how the segments of the rim overlap so as to present an unbroken belt surface.

In the invention of C. L. Rosenqvist, patented October 25, 1904, No. 773,426, the expanding pulleys are mounted on co-

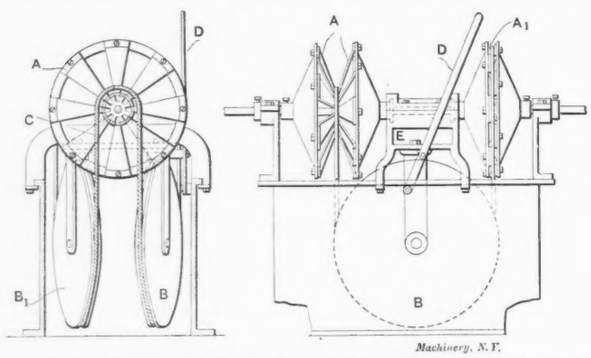


Fig. 47. C. L. Rosenqvist's Patent, No. 773,426. Granted October 25, 1904.

axial shafts and are connected by a round belt running in the V-grooves formed between $A\ A$ and $A_1\ A_1$. The belt is supported between the two pairs of cones by the idlers $B\ B_1$, which are pivoted so as to swing to accommodate the varying positions of the belt as the pulleys are expanded and contracted. In this construction it is apparent that the thrust of one member of the cones A is balanced by that of the opposite member of the cones A_1, so that the movement of lever D, which is connected to the shifting mechanism E, meets little resistance.

STANDARD HYDRAULIC PIPE FLANGES.

FRANK B. KLEINHANS.

Hydraulic machinery is used to-day in almost every line of work. In rolling mills and steel works the hydraulic system is indispensable. We also find a large field for this class of machinery in cotton presses, filter plants, riveting machinery and so on. Now with this large field for the use of hydraulic machinery there is of course a great deal of pipe fitting required. Each builder has his own idea in regard to the method of coupling the pipes, some of which are good and practical, while others are forever giving trouble. The essential features of a high-pressure pipe coupling are as follows: First, the

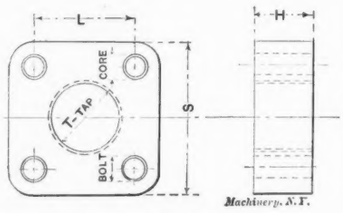


Fig. 1.

coupling should be absolutely water-tight; second, it should be so designed as to admit of being easily put together or taken apart; third, it should be simple and have the least number of parts; fourth, it should be low in price.

Fig. 1 represents a coupling which has all of the above features. This principle has been used for a number of years under the most severe strain of hydraulic piping. S is one of the sides of this square flange, L is the distance between the bolt centers, and H is the thickness of the flange. The coupling is arranged for four bolts of such size as to be suitable for

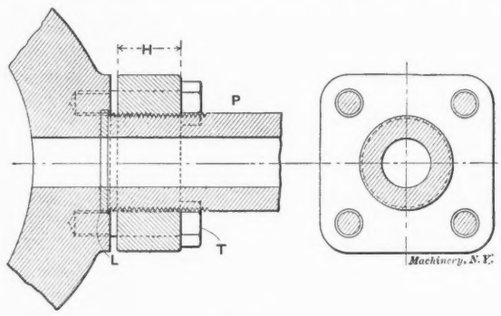


Fig. 2.

3,000 pounds water pressure. It is rare that the water pressure in any accumulator system is above 2,500 pounds; therefore this flange will be used for any pressure from 500 to 3,000 pounds. The flange would of course be stronger than necessary for the low pressure, but as this is a standard flange it is cheaper to use the same size for different pressures between these limits, as the outside diameter of the pipe is the same whether the pipe be merchant, extra or double-extra strong.

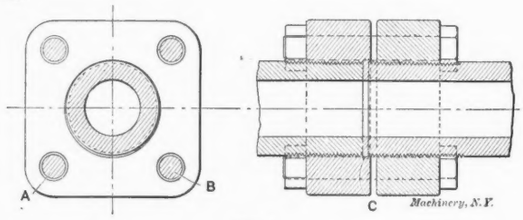


Fig. 3.

The tap T is made a medium pitch, as noted in the accompanying table, and is a straight thread. One arrangement of this flange is shown in Fig. 2. The double extra heavy pipe P is threaded about one inch more than the thickness of the flange H. The flange is then screwed onto the pipe until the end of the pipe projects about one quarter of an inch. A leather washer L is placed into a corresponding recess in the cylinder, and serves to pack the joint. The four tap bolts are used to draw the pipe against this leather packing, and thus seal the joint. These bolts should always be made tap bolts in-

stead of studs, for the reason that in nearly every case it is impossible to move a pipe longitudinally far enough to slip the flange over the studs.

It is not an infrequent thing to be obliged to couple together two pieces of pipe for a continuous line. The arrange-

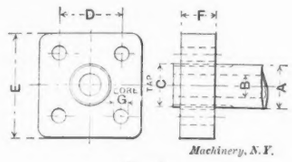


Fig. 4.

ment of the flanges for this case is shown in Fig. 3. One of the flanges is counterbored, as shown at *C*, for a leather washer. The counterbore is the same diameter and the thickness of the washer is the same as that which would be used in connecting up direct with the cylinder. See Fig. 2.

Size of Pipe	A	B	Area	Tap. C	Tap. Thds.	D	E	F	G	Bolt.	Washer. Dia.	Washer. Thick.
1¼	1.66	.88	2.2	1 11/16	12	2¼	3½	1⅜	1 1/16	⅝	1 3/4	3/16
1½	1.9	1.08	2.8	1 7/8	10	2¾	4¼	1¾	1 3/16	⅜	1 15/16	3/16
2	2.37	1.49	4.4	2 3/8	10	3¼	5	2	1 5/16	⅞	2 7/16	3/16
2½	2.87	1.75	6.5	2 7/8	10	3¾	6	2¼	1 1/16	1	2 15/16	3/16
3	3.50	2.28	9.6	3½	10	4½	7	2½	1 5/16	1¼	3 5/8	¼
3½	4.00	2.71	12.5	4	10	5	7¾	2¾	1 7/16	1⅜	4 1/8	¼

The bolt holes *A* are cored one-sixteenth larger than the bolt, and the bolts are rough forged. These flanges are made of cast iron and have no machine work in them except chasing the thread and in some cases counterboring for a washer.

The dimensions for the different size flanges are given in the cut, Fig. 4, while the table gives some data on the external and the internal diameter of XX pipe.

* * *

AMOUNT OF AIR REQUIRED FOR VENTILATION.

Under the general conditions of outdoor air, namely 70 degrees temperature and 70 per cent of complete saturation, an average adult man, when sitting at rest in an audience, makes 16 respirations per minute of 30 cubic inches each, or 480 cubic inches per minute. With 70 degrees temperature and 70 per cent humidity, the air thus inhaled will consist of about one-fifth oxygen and four-fifths nitrogen, together with about 1 7-10 per cent of aqueous vapor, and 4-100 per cent of carbonic acid. By the process of respiration the air will, when exhaled, be found to have lost about one-fifth of its oxygen by the formation of carbonic acid, which will have increased about one hundred fold, thus forming about 4 per cent, while the water vapor will form about 5 per cent of the volume. In addition, the exhaled air will have warmed from 70 degrees to 90 degrees and, notwithstanding the increased proportion of carbonic acid—which is about one and one-half times heavier than air—will, owing to the increase of temperature and the levity of the water vapor, be about three per cent lighter than when inhaled. Thus it will be seen that this vitiated air will not fall to the ground as has often been presumed, but will naturally rise above the level of the breathing line, and the carbonic acid will immediately diffuse itself into the surrounding air. In addition to the carbonic acid exhaled in the process of respiration, a small amount is given off by the skin. Furthermore, 1½ to 2½ pounds of water are evaporated daily from the surface of the skin of a person. If the air supply at 70 degrees is assumed to have a humidity of 70 per cent and to be saturated when it leaves the body at a higher temperature, then at least 4 cubic feet of air per minute will be required to carry away this vapor.

Taking into consideration these various factors, it becomes evident that at least 4½ cubic feet of fresh air will be required per minute for respiration, and for the absorption of moisture and dilution of carbonic acid gas from the skin. This, however, is only on the assumption that any given quantity of air, having fulfilled its office, is immediately removed without contamination of the surrounding atmosphere; but this condition is impossible, for the spent air from the lungs, containing about 400 parts of carbonic acid gas in 10,000, is immediately diffused in the atmosphere. The carbonic acid does not fall to the floor as a separate gas, but is intimately mixed with the air, and equally distributed throughout the apartment.

It must then be evident that ventilation is in effect but the process of dilution and that when the vitiation to be maintained in the apartments is decided, the necessary constant supply of fresh air to maintain this standard may be very easily determined. For the purpose of calculation, 0.6 cubic feet per hour is accepted as the average production of carbonic acid by an adult at rest, and the proportion of this gas in the external air is as 4 parts in 10,000. If, therefore, the degree of vitiation of the occupied room be maintained, say at 6 parts in 10,000, there will be permissible an increment of only 2 parts in 10,000 above that of the normal atmosphere, or 2 divided by 10,000 equal .0002 of a cubic foot of carbonic acid in each cubic foot of air. The 0.6 cubic foot of carbonic acid produced per hour by a single individual will, therefore, require for its dilution to this degree 0.6 divided by .0002, equal 3,000 cubic feet of air per hour.

These figures are generally applicable to the ventilation of schools, churches, halls of audience and the like, where the occupants are reasonably healthy and remain at rest. But the absolute air volume to be supplied cannot be specified with certainty in advance, without a thorough knowledge of all the conditions and modifying circumstances, in fact, the climate, the construction of the building, the size of the rooms, the number of occupants, their healthfulness and their activity, together with the time during which the rooms are occupied, all have their direct influences. Under all these conditions, it is readily seen that no standard allowance can be made to suit all circumstances, and results will be satisfactory only in so far as the designer understandingly, with the knowledge of the various requirements as they have here been given, makes such allowance.

* Extract from Treatise on Ventilation and Heating, by B. F. Sturtevant Co. Boston Mass.

* * *

WEAR OF TURBINE BLADES.

The firm of Sulzer Bros., the famous German builders of steam engines, have conducted extensive experiments upon the wear of the blades of steam turbines, to determine the cause of this trouble. It is undoubtedly a fact that the continued success of the turbine hinges largely upon this one point of blade wear. If the blades of a particular machine should have to be renewed frequently, because of deterioration and consequent loss in economy in the use of steam, that turbine would not make a commercial success. The Sulzer experiments indicate that the wear is due to the particles of water in the steam and that if water is present in steam that flows at extremely high velocities, as is the case in single-stage turbines, the cutting is apt to be rapid. With superheated steam, or with saturated steam in multi-stage turbines, the cutting is not a serious matter.

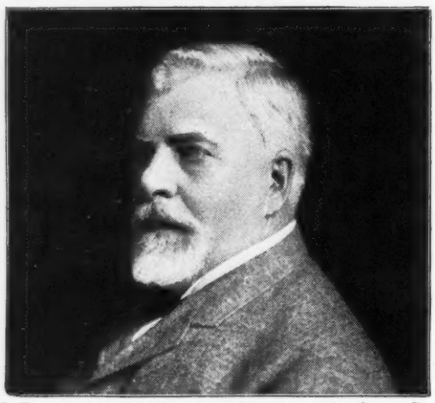
The above experiments are in a measure confirmed by the experience of those using steam injectors for boiler feeding. This cutting action seldom occurs in the steam nozzle, but frequently does take place in the combining tube where water is flowing at comparatively low velocities. It should be noted, however, that this water is mainly the feed water pumped up by the injector, and contains more or less mineral matter, the extent of the cutting probably depending upon the quantity of such foreign particles entrained in the water. In the case of the turbine, however, the water particles suspended in the steam are or should be nothing but pure distilled water, formed by steam condensation after leaving the boiler. Probably no injector would give trouble by cutting, if used to pump distilled water, assuming, of course, that the tubes were of a material that would not be corroded by the water. We also believe that no turbine, in which the steam is used at moderate velocity, will be likely to deteriorate rapidly under ordinary operative conditions.

* * *

A steel scale makes a handy screwdriver—but always use your neighbor's.

FIFTIETH ANNIVERSARY OF THE CRANE CO.

The Crane Co., Chicago, Ill., celebrated their fiftieth anniversary July 4. All of the company's branch house managers took part in the celebration. Excursions were made to various points of interest, the visitors were entertained for a part of the time at the country residence of Mr. R. T. Crane, and on July 6, the last day of the proceedings, the company gave a picnic to all its employees and their families. About 10,000 people attended this picnic.



R. T. Crane, the President and Founder of the Crane Co.

Richard Teller Crane, the founder of the Crane Co., was born at Paterson, N. J., in 1832. His parents were poor, but wished their sons to learn trades and young Crane had instruction and experience in several branches of mechanical work. He served four years in a brass foundry and also worked as a machinist for several firms, including R. Hoe & Co., New York. In 1855 he was thrown out of employment and went to Chicago, where he had an uncle, the late Martin Ryerson, who was engaged in the lumber business. He consulted with his uncle in regard to going into business for himself, and finally opened a brass foundry in one corner of his lumber yard. Being anxious to see how the furnace and sand would work, and having some patterns ready, he took off a heat the next day, notwithstanding that it was the Fourth of July. The sand used was found on the premises and the first castings were couplings used in connecting lightning rods. Business prospects looking good, Mr. Crane sent for his brother, Charles S. Crane, who came in the fall, and who was connected with the business until 1871. Shortly after his arrival they decided to go into the making and finishing of brass goods. A foot lathe was purchased, and the manufacture of brass engine trimmings begun. A few months later a room with power was rented, and the following spring a small three-story frame building was erected and equipped for power with a six horse power portable engine.

After the breaking out of the civil war the enormous demand of the government for all sorts of material made it necessary to enlarge the brass plant and the manufacture of brass globe valves, check valves, steam and gas cocks was begun. An iron foundry was started, and the building, in a small way, of machinery and the making of a few articles belonging to the steam fitting line was undertaken. About the same time a small butt-weld pipe mill, the first mill west of Pittsburg, was built on ground where the Crane Co. still has a pipe mill. In the same year (1864) the property where the present brass department is located, known as No. 10 North Jefferson Street, was purchased and the first malleable iron foundry outside of the Eastern States started. This foundry was on the second floor and is said to be the first instance of a foundry being placed above the ground floor. The manufacture of both malleable and cast iron fittings was commenced.

In 1865 the business was incorporated and the name of the firm was several times changed, becoming in 1890 the Crane Co. Fortunately the plant escaped the fire of 1871 and the demand for their goods during the rebuilding of the city required a large increase in their facilities. Many extensive additions and new buildings have been added to the plant from time to time, since 1871, however, due to the normal and steady growth of the business. In 1881 another pipe mill was erected, in which a Siemens gas furnace was employed in the manufacture of lap-welded pipe; but ultimately the machinery in this mill was transferred to a mill at Pittsburg, and the space vacated was used for additions to the malleable and grey iron departments.

Although the Crane Co. was concentrating upon the manufacture of valves and fittings, the continued growth of the business has demanded extensive additions, particularly since 1890, and this year a five-story modern office building has been erected. Not only has there been an immense increase in the floor space used for manufacturing purposes, but all departments have been equipped with the latest improved machinery, much of which has been designed and built by the company.

The company have at various times manufactured a great variety of machinery and apparatus. As early as 1857, when steam heating was a novelty, they entered this field and next year had a contract for the steam warming of the court house at Chicago. At different times they manufactured heating coils, wrought iron pipe radiators, cast iron radiators, and ventilating fans. Believing that it was not fair for the manufacturer to compete with the trade to which he was selling, they retired in 1874 from the steam warming contract business.

Elevators were made by the Crane Co. in 1867, and the business grew so rapidly that it was soon crowding other work out of the machine shop. In 1870 the manufacture of passenger elevators was commenced. In 1886 the elevator part of the business was separately incorporated as the Crane Elevator Co. and given a complete plant by itself. With a view to concentrating on the valve and fitting business, the Crane Elevator Co. was sold in 1895. While Otis Tuft, of Boston, was the first builder of passenger elevators in this country, and was followed very closely by Otis & Co., of New York, the Crane Co. took up these lines so soon after these firms that the company should be considered as a pioneer in the industry.

About 1865 the company took up the manufacture of pulleys, shafting, steam engines and steam pumps. A Corliss engine built by the company in 1879 was installed in the factory building at No. 10 North Jefferson Street, and has been in continuous hard service from that time to this day. Immediately after the great fire Mr. Crane offered to put several Crane pumps along the river and force the water through the city mains. His offer was accepted, and the water thus pumped was the only fire protection the city had until the city water works was again in operation. At present the Crane Co. does not manufacture machinery for sale, but they have a machine designing department and a machine shop in which is built the special machinery needed in the business.

Some of the important classes of goods put on the market in more recent years have been stationary, marine and locomotive pop safety valves, drainage fittings, extra heavy brass and iron valves and fittings, hydraulic valves and fittings, Ferro steel flanged fittings and valves, ammonia fittings, steam traps, steam and oil separators, malleable and Ferro steel companion flanges, electrically and hydraulically operated and steam actuated valves, and a complete line of flat band fittings.

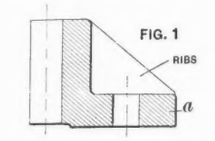
Mr. R. T. Crane, the founder, has been connected with the company since its beginning and is now its president. He has always taken an active interest in economic, political and educational affairs and is a writer upon educational problems. He lays great stress upon the importance of manual training and in 1892 equipped a manual training room in one of the Chicago schools, and employed a teacher for instruction in this department. He later provided the means required to give instruction in manual training in the lower grades of the Chicago schools and gave funds for 24 scholarships. In recognition of his interest in this branch of education, the board of education has recently named a new school the R. T. Crane Manual Training School. An active interest, also, has been taken by Mr. Crane in the welfare of his employees. Prior to the establishment of a pension system by the company he personally pensioned employees whom sickness or old age had rendered helpless, and since 1899 each employee has been presented with five per cent of his earnings of the previous year, on the first of each January, except that last year and the year before, the amount was 10 per cent.

GENERATING A LARGE INDEX PLATE.

A. L. DE LEEUW.

Much has been written about methods of generating correct index plates, but the subject is not exhausted by any means, and any new way is almost sure to be of interest to many mechanics. I would not like to take oath that the following is new, neither would I be surprised if I should hear that the Chinese used the same method for spacing the bricks in their great wall; but to me it was new, and I have no doubt it will be to a great many others.

I was up against the problem of cutting some large gear rings, 10, 12 and 14 feet in diameter respectively. They had to be cut very accurately as these gears were to be driven by two pinions, diametrically opposite each other. Such a drive requires much greater accuracy in the gear than where only one pinion drives. The reason is obvious. Take a gear with 176 teeth—every pitch might be 1/1,000 inch too large over the first half of the gear, and 1/1,000 inch too small over the last half; and the error would be so small that there would



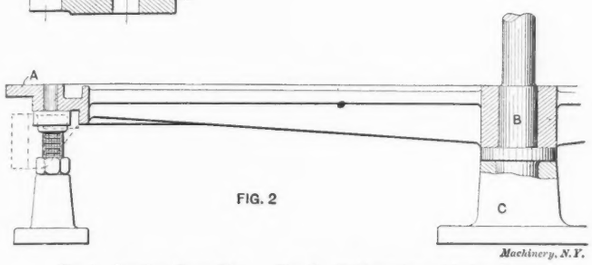


Fig. 1. Section Gear Rim. Fig. 2. Half-section of Index Plate.

be no appreciable defect in the drive, so long as there is only one pinion. But space No. 89 would be 88/1,000 inch out of place, and, when there are two pinions, it would be this space which would be acted upon by the second pinion, while the first pinion engages space No. 1. Now, 88/1,000 inch is entirely too much of an error to be neglected; in fact, such an error would condemn the whole drive. And yet, the individual error in the spaces would be so small as to make it almost impossible to avoid them. It is this possibility of errors accumulating which makes it so difficult to originate a correct dividing plate.

The gears to be cut were 150, 176, and 210 teeth respectively; 1¼ diametral pitch. They were to be cut on the slotter, as there was no gear cutter large enough to handle such work The section of the gear was like Fig. 1. The fit was at *a*. A number of bolts were to secure the gear to the table of the boring mill which it was to drive. The ordinary way to cut a gear of this type was to turn it up and fit it to a spider or index plate. The bolt holes in this spider were used as jig holes to drill the holes in the rim of the gear, thus making all gears interchangeable. The spider had notches milled in its outer circumference. This was done on the gear cutter, with the result that if the gear cutter had any errors, those errors would be reproduced in the spider. As a rule, the diameter of the spider was very much larger than the diameter of the dividing wormwheel on the gear cutter, so that the errors of the wormwheel were not only copied, but even enlarged. All this was absolutely inadmissible on this job, so new spiders were made and provided with as many holes as the gear was to have teeth. These holes were all drilled at equal distances from the center, and very accurately spaced; and, *above all*, the spacing and drilling was done in such a manner that the *errors could not accumulate.*

It is generally accepted as true that about the most difficult job in the machine shop is the drilling of a hole—in the proper place and of the proper size. It will be easily seen, therefore, how much more difficult it must have been to drill some hundreds of holes, all in their proper places. I think the methods used to accomplish this feat successfully would interest many mechanics, hence this article.

The plate to be divided was first turned true and with a smooth surface, *A*, Fig. 2. It is the under side of the spider, but is the side used for dividing. The gear is shown in place, though this was not the case while the spacing was being done. The spider was pivoted on a stud, *B*, held in a stand, *C*. The outer rim of the spider was supported by numerous jackscrews, with brass caps, allowing the spider to slide over the jacks, but preventing it from sagging. The jackscrews were locked in position, as shown.

On stud *B* two arms were mounted. These arms were about 7 feet 8 inches long from the center of the stud to the outer end. They were made of cast iron, and as light as was consistent with the required stiffness. Both arms would turn around the stud. The bearings on the stud were, of course, one above the other, but the main part of the arms were in the same plane. When in position they formed a pair of large jaws. A hardened steel hook was fitted to the end of each arm, and these hooks coming in contact when the arms were a certain distance apart made this distance the maximum space between them.

Fig. 3 gives a diagrammatic view of the above arrangement. *A* is the plate or spider to be spaced. *B* is the stud around which the arms *C* and *D* turn. *E* and *F* are the hooks or limiting pieces. The arm *C* is provided at its extreme end with a piece holding a hardened steel pin, *G*, rounded at its end. This piece could swivel, so as to allow the pin to point in various directions. When once adjusted, the swiveling piece, was clamped in position. The other arm *D* had a similar swiveling piece, which was split and provided with a clamping screw. It was tapped out, and held a micrometer screw, which could be clamped by means of the split bearing and clamping screw. The end of the screw was rounded over, and the head was made large and divided so that one division corresponded to one-half thousandth of an inch. No attempt was made to have this screw, or the divisions on the head, very accurate; it was used as it came from the lathe, for as will be seen later on, accuracy of this screw would serve no purpose. A pointer was fastened to the swiveling piece. This pointer was simply a piece of sheet steel with beveled edge, and long enough to be always over the screw head. The piece, *G*, and the screw, *H*, were adjusted, so as to be in line when butting up against each

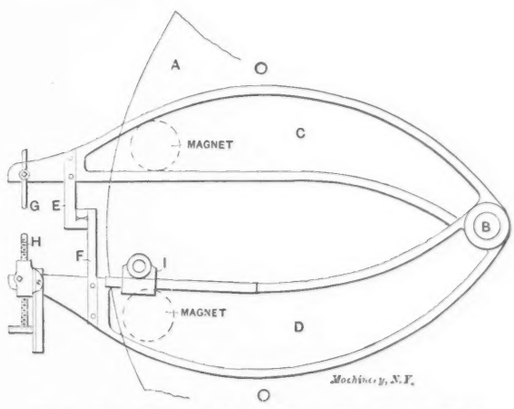


Fig. 3. Plan of Arms, which are Mounted on Stud B, Fig. 2.

other. In this manner, the movement of the arms relative to each other was limited both ways: one way by the hooks, and the other way by the pieces, *G* and *H*.

The mode of operating was as follows: one arm was pulled back until the arms came in contact, when it was clamped to the spider. Then the other arm was moved up, until the screw *H* struck the pin *G*. This arm was then clamped, and the other released. The first arm was then pulled back again, and these operations were repeated, thus moving both arms all around the spider. The arm *D* was provided with a planed edge, to which a piece, *I*, was securely fastened. This piece is shown in detail in Fig. 5. It consisted of a slide, carrying a jig eye or bush, to be used later on for drilling the holes. It also carried a brass block, *J*, which was carefully scraped to a bearing on the spider. To the block was screwed a glass-hard steel piece *K*. with beveled edge, and located about 1/1,000

inch above the spider. This steel piece formed a scratch edge for marking lines on the spider. A line was marked on the spider and the screw set so as to get approximately the correct division. The arms were then brought around as described, and, after the required number of spaces was made, the distance was noticed from the scratch edge to the starting line. This would give some idea as to how much correction was to be made, and the correction was made by means of the micrometer screw.

As stated before, no attempt at accuracy was made. In fact, and this will be clear by this time, the whole method is one of trial. It is the same as spacing with a pair of dividers; but, where dividers fail, this method succeeds. Any one who ever tried to space with dividers knows how impossible it is to get the same result twice. The point slips off in some minute hole of the iron, or the angle at which the dividers are held varies, or some other little thing happens, which makes the result unreliable. If one succeeds in setting the dividers so as to come back to the starting point, say after 176 steps, this same setting will give entirely different results if the same man goes around once more.

The clamping of the arms is accomplished by means of electro-magnets, fastened to the under side of the arms. The magnets were wound so that they would stay cool on a 220-volt circuit, when in series with a 110-volt 16-candle-power lamp. This lamp acted as pilot lamp, indicating when the current was turned on, and also indicating when something was wrong with the winding. And, by the way, this happened a few times; the magnets being home-made affairs. It is obvious that, holding the arms in position by means of magnets,

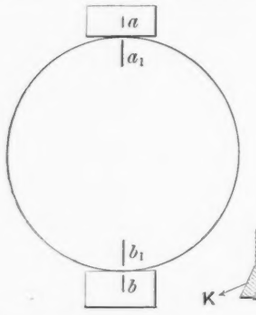


Fig. 4. Diagram showing Method of Halving the Circumference.

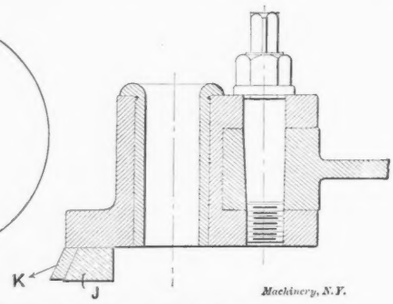


Fig. 5 Slide Carrying Jig Bushing and Scribing Edge.

is far superior to clamping, as the latter method would easily throw them out of square. Even the magnets were liable to cause trouble, as I found to my regret. This trouble did not occur on the job I am describing but on a previous job, when I and every one else engaged on it was as green as a meadow in spring time. If the surface of the plate is not perfectly level, smooth, true, well supported at frequent intervals, and on a rigid foundation, where it is not disturbed by vibrations of nearby machines, and if the magnets are not scraped nicely to a bearing with the plates and also to the arms, and if they are not protected, so that no dirt can creep between them and the plates, and if one of several other things is not provided for, then, well—then there is trouble. And the trouble with this trouble is that it does not show up until one has gone clear around the circle; and even then it may not be immediately discovered. One may find an accumulated error of 1/16 inch after going once around; one may correct for this amount, and, after going around once more, one may find an error in the other direction. Trial after trial may not produce any better result, and one may think that it is simply bad luck in estimating the correction to be made; whereas, in reality it is simply the result of poor working conditions. Great care and an infinite amount of patience are necessary, but with those elements at hand, the method gives fine results.

To start the spacing, two lines diametrically opposite each other were marked on the plate. To get these lines correct the following method was used: Two stations were erected at opposite ends of a diameter of the plate, or at least nearly so. These stations were merely castings blocked up to the proper height, so as to bring their top surfaces level with the top of the plate. A piece of sheet brass was fastened to one of the stations; the other station received an adjustable piece of sheet brass. Lines were drawn on these pieces of brass, so as to be nearly in line with each other and with the center of the spider. This, of course, was merely guesswork. These lines were extended onto the plate, so that the whole thing looked as shown in Fig. 4. The two lines on the brass are marked *a* and *b;* and the two extensions of these lines on the plate, a_1 and b_1. The plate was now turned until b_1 came exactly opposite *a*. Now, if the lines a_1 and b_1 are exactly diametrically opposite each other, then the line a_1 is bound to come exactly opposite the line *b*. This, of course, was found not to be the case. The distance between a_1 and *b* was now carefully divided in two equal parts, and a new line, a_1 and *b* (one an extension of the other) was drawn on the brass and on the plate. Then another half turn was given to the plate, and the line a_1 was brought opposite the line *a*, and the error (if any) noticed. This was repeated until no further error was discovered. The object of dividing the plate in two equal parts was simply to facilitate the first attempts at spacing as an appreciable error could be discovered by going only half way around. The lines a_1 and b_1 were not used, however, for the final spacing.

The distance was measured from the center of the stud to the center of the micrometer screw. No accuracy was aimed at. Measuring within ⅛ inch was good enough. From this measurement, the circumference of the circle, described by the screw point, was computed. This was divided by say 176, and the quotient was the distance from the point of the hardened plug to the point of the micrometer screw. A pair of inside calipers was used to set the screw to this distance. Then, 88 such distances were spaced, and the result noticed. Suppose the scratch block was ⅜ inch from the line b_1, then an adjustment was made of 1/88 part of ⅜ inches, or about 4¼ thousandths of an inch, which is about 8½ divisions of the micrometer screw head. It would have been a difficult matter to estimate the amount of correction to be made, if not assisted by the micrometer screw. One must not expect to "hit it" the first time, but considering the difficulty of the job it is surprising how few trials are necessary to get perfect spacing. It never took more than one day (of ten hours) to get a perfect spacing, after everything was rigged up. When the scratch block comes to the edge of the first line, after the required number of steps, the spacing is considered finished. It remains, however, to prove that this result was not obtained by some "lucky" mishap, or rather by some hidden defect. For this purpose we would go around once more. If again the scratch block came against the outside edge of the first line, it was considered safe to proceed with the next operation —the drilling of the holes. The first work was to step around again, and to draw a line along the scratch block at every step, thus marking a line for every hole to be drilled. This operation was an additional check on the accuracy of the spacing. There were to be 210 holes in the largest spider. Stepping around three times (once for the last trial, once for checking and once for marking the lines) required 630 spaces. The lines drawn were at the most 2/1,000 inch wide. A magnifying glass was used, to see if the scratch block came up against the line; so that it is safe to say the error was less than 2/1,000 inch. This means that the error in the individual spaces was less than 1/630 part of 2/1,000 inch. This seems too good to be true; but it was done several times in this job, and had been done in 10 circles of holes in a previous job.

One of the two arms was now removed from the spider, the arm with the drill jig remaining. A radial drill had previously been put in place, and the dividing arm was secured against the radial drill column. The spider was rotated under the arm by means of block and tackle, so as to bring the consecutive lines against the scratch block. A magnifying glass was used to locate the spider accurately. The hole was then drilled 1/32 inch small. The holes were to be 1 inch ultimately, so that a 31/32 inch drill was used. The drill was then replaced by a reamer a couple of thousandths below size, and the reaming was done by power. It goes without saying that the drill jig was taken out, and a new one corresponding in size with the reamer was put in place. After this operation was completed, the jig eye was removed once more, and a new one was inserted, having a bore of 1 inch exactly. This jig was used for reaming by hand.

The question will naturally present itself to the reader: Why was the second arm taken away? Why was not the same method used for drilling as was used for spacing? This was done originally, and could be used if it were necessary, but there were two reasons why this was not done. The first one is that, in that case, the spindle of the drill must follow the work, for the arms would take different positions on the spider, and arms and spider would have to be brought back under the drill spindle, or, in case of a radial drill being used, the drill spindle might be brought back over the jig eye. This would mean very careful adjustment, repeated many times. By leaving the drill spindle stationary, and the arm blocked up against the column, the relative adjustment of drill spindle and jig eye is preserved. The second consideration is of an entirely different nature. Electro-magnets were used for the purpose of holding the arms in place. This proved to be an excellent method; in fact, it would have been absolutely im-

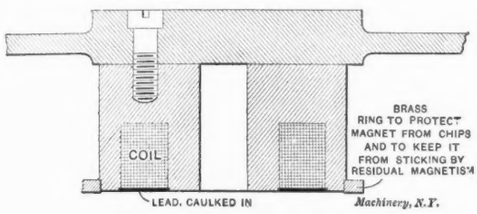
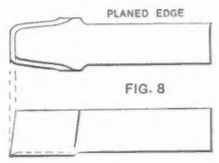

BRASS RING TO PROTECT MAGNET FROM CHIPS AND TO KEEP IT FROM STICKING BY RESIDUAL MAGNETISM
COIL
LEAD, CAULKED IN
Machinery, N.Y.

Fig. 6. Cross-section of Magnet.

possible to hold the arms without springing, and with uniform pressure by other means. But, when drilling, chips would crowd themselves between the magnet and the spider, in spite of all precautions, even though the plate was cleaned after drilling a hole. These little chips, perhaps too small to be seen, would tilt the arm forward, and crowd the drill. For these reasons, magnetism was not admitted while drilling, the clamping being done by an ordinary C-clamp. It is true that the setting of the arm was not so perfect as when done by means of the spacing method, but it was good enough for the purpose, for it must not be forgotten that it was not the object to get a gear with absolutely even pitches, but one with reasonably correct pitches, and where the errors *would not accumulate*. This latter requirement was taken care of by the method of spacing, and a good mechanic can set an edge so close to a fine line that the error is not appreciable in a gear of 1¼ diametral pitch. A good device for protecting a magnet from chips, however, is shown in Fig. 6.

The above work was done under my instructions, but credit is due to Mr. Julius Kreis, a designer of The Niles Tool Works, who made the drawings and personally supervised the work, and to Mr. Henry Moser, machinist at the above works, who brought the work to a successful end.

It may be of some interest to know something about how the gear was actually cut. This was done on a slotter, specially designed and used for similar purposes. The Niles Tool Works Company keep two of these slotters busy practically all the time. They are used for all internal gears, and for external gears which are too large in diameter, or of too heavy a pitch to be cut on an ordinary gear cutter. The table is very long and in the shape of a cross, thus giving a large surface for the support of the spiders, without making the table too heavy. For unusually large gears additional supports are provided, in the nature of stands placed around the machine, each on its own foundation. A T-slot runs the long way of the table and exactly in line with the center line of the ram. A stud and bush, held in this T-slot, serve as pivot for the spiders. The lower end of the ram has a square hole to take the tools, which are placed in horizontal position. Fig. 8 is a sketch of such a tool. The shank of the tool is planed to a gage, so that the center line of the tool has always the same distance from the planed side of the shank. Inserting the tool in the square hole, and forcing it up by means of setscrews against one side of this hole, brings the center line of the tool in line with the center line of the machine, and thus with the center line of the gear to be cut. The gear blank is fed toward the tool until within one or two hundredths of an inch of the required depth, when the power feed is thrown out, and the blank is further fed by hand. A stop prevents the operator from making a mistake as to depth. In addition, several other precautions are taken. The pitch line, and the bottom line of the teeth are marked on the blank by means of a scratch gage, shown in Fig. 7. In case the teeth are blocked out in the casting (for the purpose of securing a better casting, at least around the teeth) the operator first goes once around, outlining the tooth shape on the blank, to make sure that there is sufficient stock for every tooth. In order to do this outlining he brings the tool down to within 1/32 inch from the blank, and marks around it with a scratch awl. A screw is used to move the blank when it is unusually heavy. Otherwise this spacing is done by hand. The notches, milled in the outer rim of the ordinary spiders, are engaged by a stop pin, which indexes the gear. In the case of our gears, however, holes were used and a pin located under the spider, and held by a suitable bracket. The pin was withdrawn by means of a lever.



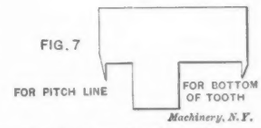


Fig. 8. Gear Tooth Tool for use in Slotter. Fig. 7. Gear Tooth Gage.

The gears proved to be excellently spaced, and the two driving pinions showed a perfect bearing on the gear teeth. Though the side clearance in the teeth was only 1/100 inch such a thing as a bearing on the back of a tooth never occurred.

* * *

AN INTERESTING GRINDING OPERATION.

The George Gorton Machine Co., Racine, Wis., build an engraving machine in which half-round pointed cutters, revolving at high speed, are employed to execute the design, being guided by a pantagraph which reduces the copy to the desired proportion. The copy to be duplicated is held in a copyholder, and by means of the pantagraph the operator accurately duplicates it by tracing its outline with the pointer at the long end of the arm. In order to produce an engraving that shall be smooth and free from ragged lines, the highest order of workmanship is required in the construction of the pantagraph and the cutter spindle. The joints of the pantagraph must work with the utmost freedom, yet be very closely fitted, hence they are made with ball bearings. As the spindle is required to run at very high speed, it must be perfectly balanced and well lubricated to prevent heating. Moreover, perfect balance is required to avoid vibration which would be destructive to good work. Fig. 1 shows the vertical cross-section of the cutter spindle and the sleeve in which it runs and Fig. 2 shows the spindle twice the full size, with the working dimensions and other details. After the spindles are turned and bored on the lathe, they are hardened and ground on a Landis grinder, and then lapped to a nicety. The grinding operation is one of considerable difficulty because of the extreme accuracy required in the concentricity of the taper bore for the cutter shanks and the external bearings. At our request the operator of the grinding machine, Mr. Philip Korzilius, has kindly described for us the steps followed to produce accurate spindles:

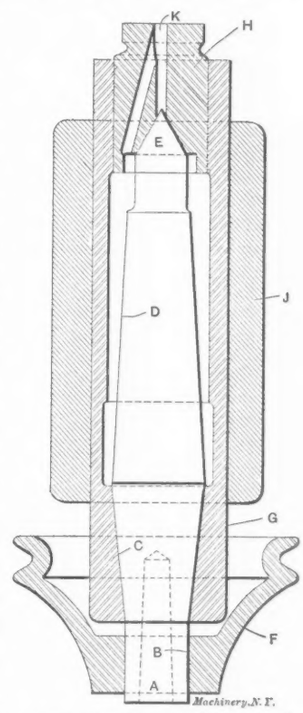


Fig. 1. Section through Spindle Bearing of Engraving Machine.

The hardened spindle is first mounted on a plug fitting the

taper holder in the grinder spindle and the grinder head is set to an angle of 30 degrees in order to rough-grind the 60-degree thrust bearing *E*. Then, without moving the work, the tailstock is run up with a female center to fit the 60-degree point just ground. The grinder head is swung back to zero and the grinder bed is set to a taper of ⅝ inch to the foot to grind the spindle at *D* for a future operation.

various grinding operations outlined in the foregoing follow progressively as each operation on the lot is completed.

The sleeve in which the spindle runs is also made of tool steel hardened and accurately ground for the lower bearing taper; also for the upper thrust bearing, and on the outside. The upper thrust bearing is merely dropped into position, being pushed down very lightly against the 60-degree thrust

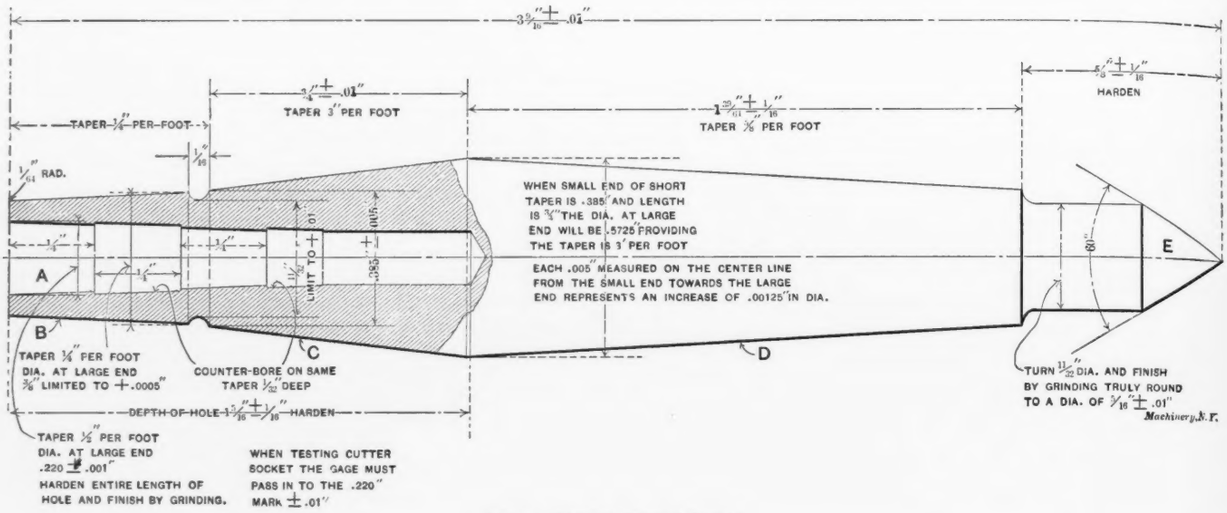

TAPER ¼" PER FOOT
TAPER 3" PER FOOT
TAPER ⅜" PER FOOT
HARDEN
WHEN SMALL END OF SHORT TAPER IS .385" AND LENGTH IS ¾" THE DIA. AT LARGE END WILL BE .5725" PROVIDING THE TAPER IS 3" PER FOOT
EACH .005" MEASURED ON THE CENTER LINE FROM THE SMALL END TOWARDS THE LARGE END REPRESENTS AN INCREASE OF .00125" IN DIA.
A
B
C
D
E
TAPER ¼" PER FOOT DIA. AT LARGE END ⅜" LIMITED TO +.0005"
COUNTER-BORE ON SAME TAPER ½" DEEP
TURN 11/22" DIA. AND FINISH BY GRINDING TRULY ROUND TO A DIA. OF 7/16" ± .01"
Machinery, N. Y.
TAPER ½" PER FOOT DIA. AT LARGE END .220 ± .001" HARDEN ENTIRE LENGTH OF HOLE AND FINISH BY GRINDING.
WHEN TESTING CUTTER SOCKET THE GAGE MUST PASS IN TO THE .220" MARK ± .01"

Fig. 2. Enlarged View of Spindle.

The second operation consists of three steps: The work, which now has been ground to a ⅝-inch taper, is placed in the taper hole in the grinder spindle, and the first step consists in rough grinding and finish grinding the pulley taper *B* at cutter end of spindle; which is done with the bed set to a taper of ¼-inch per foot. The second step of the operation consists of rough grinding the lower bearing *C* just above the pulley taper. This is done with the grinder bed set to a taper of 3 inches per foot. The third step consists of the rough and finish grinding of the internal taper *A* for the cutter shanks, and this is done with the grinder bed set to a taper of ½ inch per foot. It will be noticed that the taper hole is counterbored on the lathe to form clearances for the grinding operation.

The taper hole for the cutter shanks having been finished, the third operation is the same as the first operation, the work being mounted on a plug in the grinder spindle in order to finish grind the 60-degree thrust bearing *E*, which was rough ground in the first operation. In this case, as before, the bed is set at zero and the head at an angle of 30 degrees. After finish grinding, the head is swung back to zero and the female

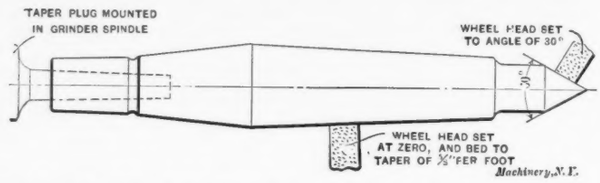

TAPER PLUG MOUNTED IN GRINDER SPINDLE
WHEEL HEAD SET TO ANGLE OF 30°
WHEEL HEAD SET AT ZERO, AND BED TO TAPER OF ½" PER FOOT
Machinery, N. Y.

Fig. 3. Method of Grinding Upper End of Spindle, first and third Operations.

center in the tailstock is run up to support the 60-degree point, and the parallel portion immediately below the taper is then ground, but the size is not material as this portion is not fitted to any other part. With the female center still in place, the bed is swung to a taper of 3 inches per foot, and then the lower bearing *C* is finish ground which was rough ground in the second step of the second operation. This brings both bearings, lower *C* and upper 60-degree thrust *E*, true with each other and concentric with the internal taper.

All sizes are tested and maintained by special working gages which in turn are tested periodically with master gages. The great difficulty in obtaining an accurately finished cutter spindle of the dimensions shown in the drawings, is caused by a comparatively small diameter of the taper hole for the cutters. Of course, the spindles are made in lots, and the

bearing on the cutter spindle and the barrel, being split at this end, is clamped over the thrust bearing, thus holding it in the desired adjustment. This construction of spindle and sleeve

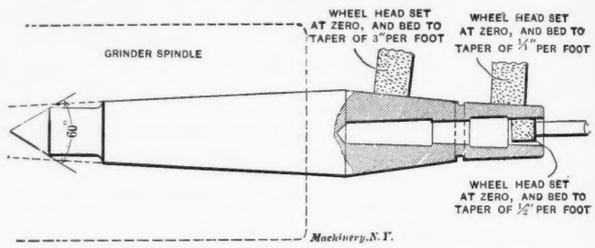

GRINDER SPINDLE
WHEEL HEAD SET AT ZERO, AND BED TO TAPER OF 3" PER FOOT
WHEEL HEAD SET AT ZERO, AND BED TO TAPER OF ¼" PER FOOT
WHEEL HEAD SET AT ZERO, AND BED TO TAPER OF ½" PER FOOT
60°
Machinery, N. Y.

Fig. 4. Method of Grinding Lower End of Spindle, second Operation.

makes the removal of the spindle from the barrel for cleaning a very simple operation. The makers say that it can be removed, cleaned and reassembled accurately in one minute.

* * *

TESTS OF HELICAL SPRINGS.

The Watertown Arsenal has made quite extensive tests of helical springs used in gun carriages. A spring having a free height of 28.3 inches, exterior diameter 7.61 inches, diameter wire 1.25 inch, distance between coils 0.95 inch, weight 93 pounds, was compressed to 23 1-18 inches when loaded with 5,290 pounds. A load of 11,800 pounds compressed the spring practically solid, in which condition it measured 16.82 inches high. A spring 21.4 inches high, exterior diameter 4.2 inches, diameter wire 1 inch, distance between the coils 0.28 inch, weight 27½ pounds, was compressed to 19⅜ inches with a load of 4,400 pounds, and was compressed practically solid (height of 17.06 inches) under a load of 9,300 pounds. Sixty springs for 7-inch mortar carriages were tested. The height of these springs was 18.8 inches, exterior diameter 5.08 inches, diameter wire 0.70 inch, distance between coils 0.86 inch, weight 18¾ pounds. A load of 1,250 pounds compressed a spring to 15 inches, and 2,920 pounds compressed it to a height of 9½ inches. When closed down solid the height was 9.08 inches and the load was 3,500 pounds. Twenty of these springs were closed down to a height of 9½ inches for a period of 64 hours, and immediately after their release the free heights were measured and again later after remaining unloaded 48 hours. The average decrease in free height was 0.19 inch immediately after release, and after 48 hours it was 0.14 inch. In other words, the springs recovered 0.05 inch of the set.

WHY STEEL CAN BE CUT FASTER THAN CAST IRON.

In a paper, "High Speed Tool Steels," read by Mr. Arthur B. Corby before the Salford Science Students' Association, April 8, 1905, the author very clearly told why steel can be cut faster than cast iron: "With all the tool steels working on steel at high speeds the continual rubbing of the shaving on the upper surface of the tool wears more or less of a pit on the surface. At the same time, on the extreme point of the tool a small accumulation of portions of the material being cut gathers, being practically welded to the tool. Now, the position of the pit on the upper surface of the tool is situated further back from the cutting edge with a deep cut than with a light one. This is owing to the tenacity of the steel, and is not found to be the case in turning cast iron. The tenacity of the shaving and the action of the tool as a wedge cause the actual point of cleavage to be in advance of the extreme edge of the tool. The larger the chip, the greater its strength is, and therefore the further back on the tool it slides, making a greater angle between the shaving and the work wherein the front of the tool is more or less clear. The tool splits off the shaving of material like an axe cleaving wood with the grain. After having once entered, the cutting edge of the axe is clear, while the thicker part of the axe, acting like a wedge, forces the wood apart. In my opinion, the action of the tool in cutting steel is similar, and with the larger cuts the greater part of the work is done well back on the tool, where there is a good body of steel. In a lighter cut the shaving wears a pit right up to the cutting edge, thereby weakening it, and causing it to break down sooner. With cast iron, owing to its brittleness, the action is different, and the work is practically all concentrated on the cutting edge. When the tool first penetrates a piece of iron is broken off for a little distance in advance of the tool; the roughness intervening is removed as the work revolves against the tool, the point of which again penetrates and breaks off a portion, and so the action continues."

TRAVELING JIB CRANE AND TRAVELING JIB DRILL.

The large erecting floor shown in Fig. 1 is that of the Bucyrus Company, of South Milwaukee, Wis. This concern, which normally employs something over 800 men, builds steam shovels, hydraulic dredges and locomotive cranes, and it is here that the 94-ton Bucyrus steam shovels which are now being used in digging the Panama Canal were constructed. In building steam shovels the frames are erected on the trucks and the superstructure follows, the work being conducted in substantially the same manner as cars or other rolling stock are built. A great deal of drilling has to be done as the erection proceeds, and for this work the traveling jib drill shown in the half-tone, Fig. 2, and in the line cut, Fig. 3, is employed. The general view of the erecting floor, Fig. 1, however, does not include it. This machine has a radial arm about 14 feet long, which, with the available longitudinal movement, enables the drill spindle to be used for drilling vertical holes on any part of the steam shovel in construction. As is evident from an inspection of Fig. 2, the drill spindle is operated by an electric motor mounted on the radial arm; the panel for the starting box is fastened to the side of the arm, in which position it is convenient for the operator. The armature shaft is geared to an intermediate shaft on which are mounted the back gears at the left of the controller for changing the speed. The feed mechanism is extremely simple, the rate of feed depending entirely on the weight and disposition of the man at the end of the lever arm!

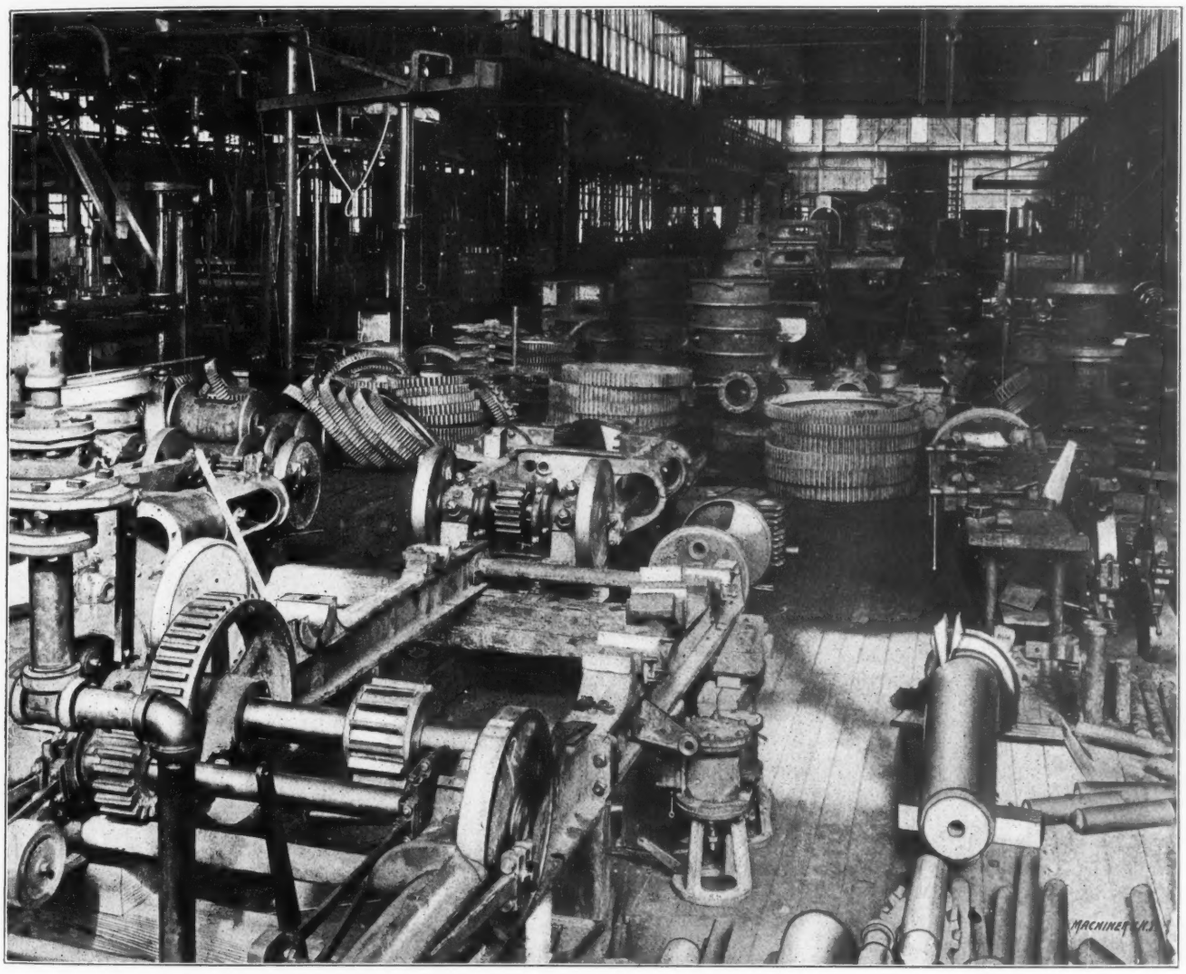


Fig. 1. Erecting Floor of the Bucyrus Company's Shops, showing Typical Dredge Work in Process of Erection.

Behind the traveling jib drill is another track, shown in Fig. 3, on which is operated a traveling jib crane of 7,000 pounds capacity for handling plates. This crane is mostly used in the plate shop, but may be employed for transporting material from the plate shop to the storage yard when occasion requires. It is shown in the half-tone, Fig. 4, and the line cut, Fig. 5, which gives the principal dimensions and the

arrangement of the operating machinery. This type of crane is one that can be very profitably employed in many shops that are now struggling along with inadequate handling facilities because the managers are, perhaps, under the impression that the traveling crane is the only satisfactory means that can be installed to meet their requirements. But in shops of old construction not designed for supporting heavy weights, the roofs are generally too weak or not properly constructed for installation of the traveling crane, and the Bucyrus plate shop is an example. The walking crane, however, "fills the bill" to perfection and imposes no severe stresses on the roof trusses. As is quite evident, only a single track is required to support the weight of the crane, and the top support is taken from the girder at the side. The top support, shown in the half-tones, is the lower part of the traveling crane track, but in the plate shop it is the side of the clear-story. The frame of the walking crane is narrow, so that a clear space of only about three feet wide is necessary for its passage. The swinging arm covers the full width of the middle bay of the plate shop, which enables the operator to pick up work in any part of the floor and transport it to any other place within range of the arm. The operator's stand, it will be noted, is shown at the left in Fig. 4, a low platform being constructed for the purpose, where he has the controller and brake at hand, and a clear view of the floor and the work to be picked up. An objection that might be raised to the use of the walking jib crane is the apparent danger of the workmen being caught and crushed by the wheels. But this is largely imaginary, for simple guards in front of the wheels push anything out of the way; and it is said that during the years it has been used in the Bucyrus shops not a single accident has occurred from its use.

A large part of the work seen in the erecting floor view, Fig. 1, is for hydraulic dredges of the type which is being largely used in the West for placer mining. Some of these dredges, such as are now in use near Oroville, California, are of enormous size and power; for example, the largest size built has 60 buckets on the chain, each bucket holding 13 cubic feet. The drums over which the chain is wound are

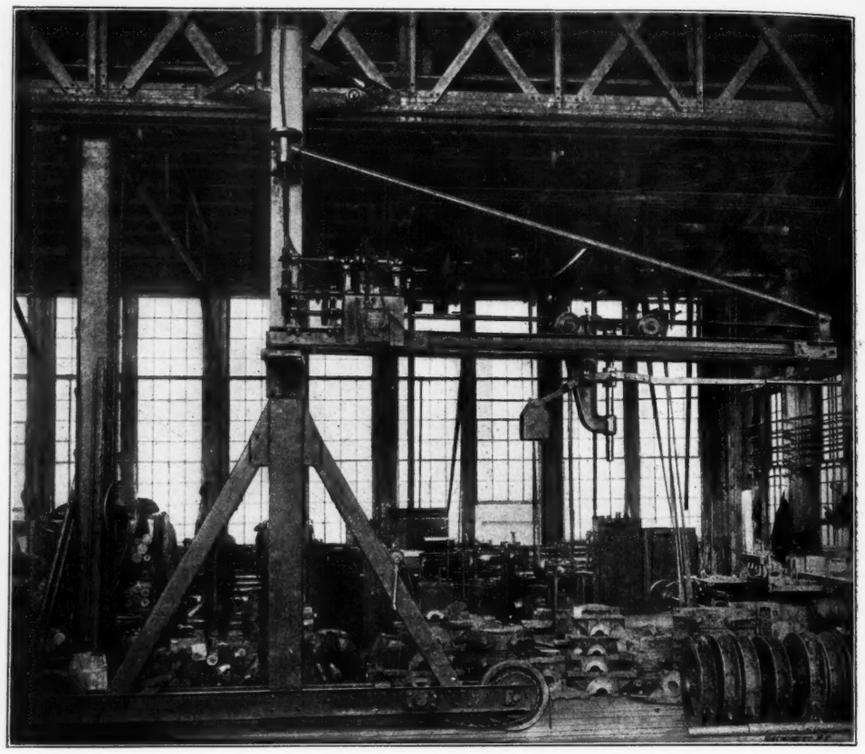


Fig. 2. Traveling Jib Drill.

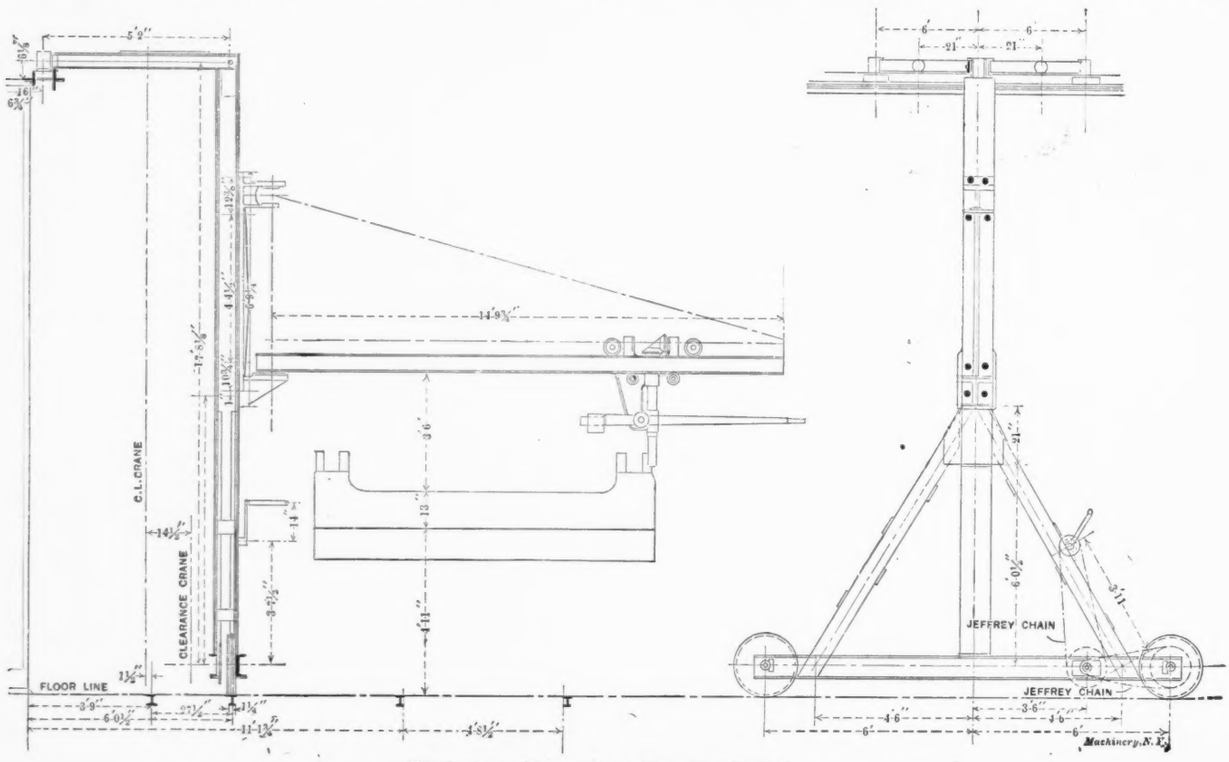


Fig. 3. General Dimensions of Traveling Jib Drill.

huge hexagonal steel castings with grooves to engage lugs on the chain. The steel casting which forms the link and foundation for the bucket weighs something over 3,500 pounds each. The lips of the buckets are made of manganese steel and the pin holes in the links are fitted on one side with a half-bushing of manganese steel. The manganese parts are very hard and tough and all holes must be cast exactly where wanted, as it is impossible to drill or machine them in any other way but grinding. The gears shown in the general view are used in the operating machinery of the dredges, one large spur gear being mounted on the shaft with the hexagonal winding drum. In the largest type of hydraulic dredge this gear is about 14 feet diameter. It is made with a steel rim and hub and cast-iron spider.

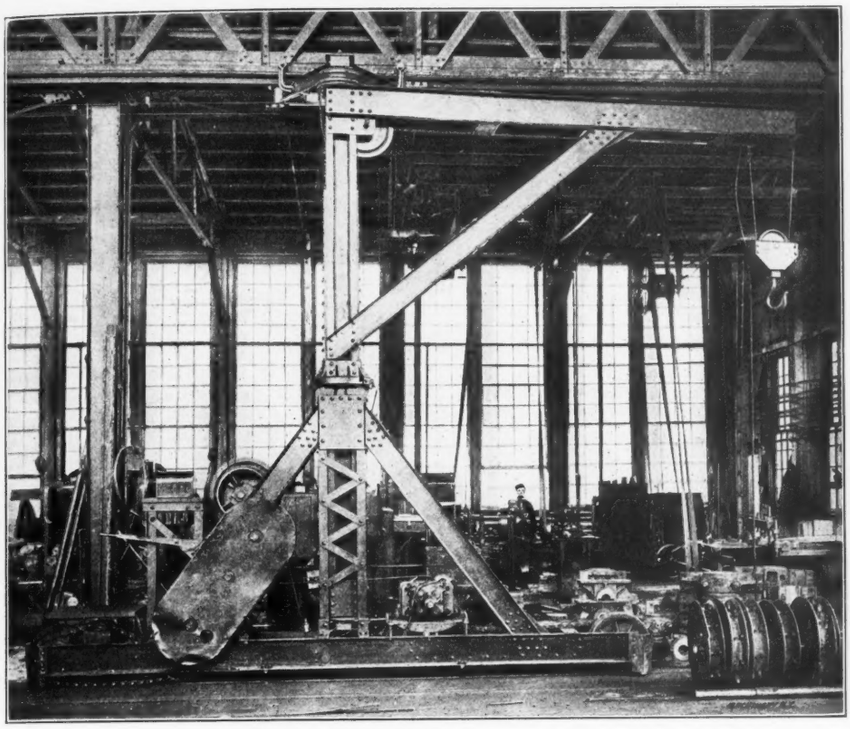


Fig. 4. Traveling Jib Crane.

SOLDERING ALUMINUM PATTERNS.*

The objection most often heard to aluminum as a pattern metal is that "it can't be soldered," or that "it is extremely difficult to solder," or that "a good joint can't be soldered." Now it is proverbially hard to prove a negative, and it is especially true in this case. The chief difficulty in soldering aluminum lies in not knowing how. It is not generally known that a fair job of soldering can be done upon aluminum with common half-and-half solder, but such is the case. We have patterns which have been in use a long time upon which are shrinkage holes soldered with the common solder. It is only necessary to follow the directions given below for using aluminum soldering, using no flux. Also, aluminum with 10 per cent. tin added will solder better with common solder. However, a special aluminum solder is much better, making a stronger job and being easier to use. We have been experimenting and testing aluminum solders for several years, and have found the one below is best, considered from all points, for metal pattern work. It is slightly different in color from aluminum, which makes it useless for ornamental work, but it is cheap, easy to use, and very strong and durable. We have made test joints with it which have stood more strain than the aluminum itself, the casting breaking at one side of the joint, though, of course, this is not usually the case. The recipe for this solder is as follows, all parts to be measured by weight: Aluminum, 1 part; phosphor-tin, 1 part; zinc, 11 parts; tin, 29 parts.

In making this solder, melt the aluminum first. Then add the zinc in small pieces, so as not to solidify the already melted aluminum. Then add the tin, taking the same precaution

* Extract from article, "Aluminum as a Pattern Metal," by H N. Tuttle in *The Foundry*, June, 1905.

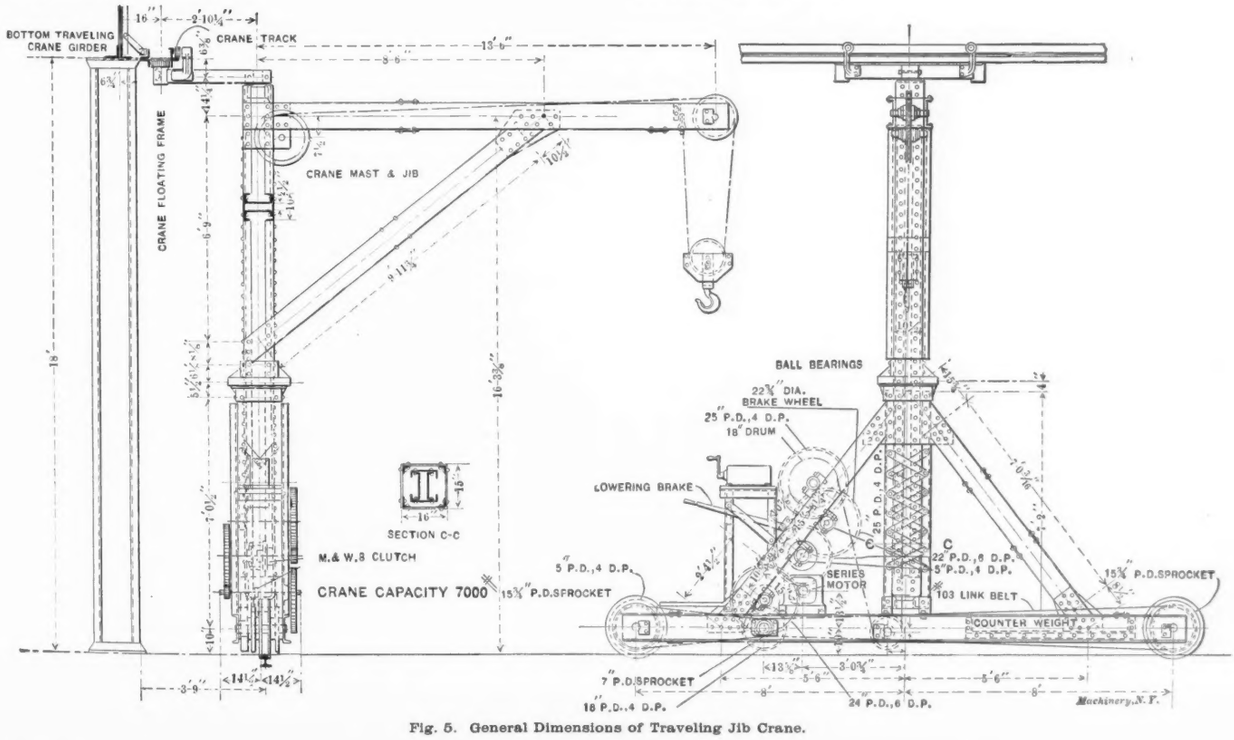


Fig. 5. General Dimensions of Traveling Jib Crane.

not to solidify the metal, and lastly, drop in the phosphor-tin, stir well with a brass rod, and quickly pour into molds, which may be easily made in the open sand. Use a crucible in making this solder.

The reason for observing the above order of melting is that if the metal with the lower fusion point were melted first, and then brought up to the temperature necessary to melt the aluminum, the lower metal would be over-heated and partially vaporized, thus destroying the proper proportion.

In regard to using the solder, it is well to understand a few points about aluminum oxide. This oxide is a thin film or skin which forms upon the surface of aluminum immediately upon its coming in contact with the air. This oxide forms practically instantaneously, so that if a scraper or other instrument be pushed across the surface of the metal, the oxide forms before the bare metal comes in sight. It also forms upon the molten metal, and it sometimes happens in pouring, that the workman finds he is pouring his metal through a tube of oxide. It also sometimes happens that when he overfills his flask, and the metal runs over the side, in the case of heavy casting, a film will form around the overflow, and siphon quite an amount of metal from his sprue, unless he prevents it by breaking the skin.

The oxide is very durable and impervious, so that it prevents the air from reaching the inner metal, and thus further oxidation is very slow. In the case of iron, the oxide is, we might say, very porous, so that the first thin layer of oxide has little effect in reducing further oxidation. Now solder will not adhere to any metal covered with oxide. In the case of brass, the oxide is removed by the flux, but there has been no flux discovered which will remove or dissolve aluminum oxide. However, the difficulty is overcome in a very simple way. The soldering copper, which should be a rather heavy one, and untinned, is heated to a dull redness, and then rubbed back and forth upon the surface to be soldered, melting the solder upon the hot copper at the same time. The surface becomes covered with the melted solder, which excludes the air and prevents further oxidation, while the point of the copper scratches off the oxide already there. Under these conditions the solder readily adheres to the aluminum, and the surface becomes "tinned." For filling shrinkage holes, or building up additions upon patterns, all that is necessary now, is to melt in the required amount of solder.

In case it is desired to solder two pieces of aluminum together, both surfaces should be "tinned," the pieces brought into position and the joint heated with a copper or blow-torch until the solder is liquid, then pressed into place and allowed to cool. Brass must be heated to 460 degrees before solder will adhere to it, while aluminum must be heated about 200 degrees higher, so it will necessarily be a little harder to solder aluminum than brass.

There is a certain stage during the cooling, just before solidification, when the solder may be worked into any shape, at will, like snow, when it is right for packing, or like the amalgam used by dentists. Of course this temperature is hard to maintain, but the temperature at which aluminum "tins" nicely, is nearly at the "wiping" temperature, as a plumber would say, and on this account there is time enough to "strike off" surplus solder, in simple cases.

As an example, suppose it is desired to "build up" a certain surface of a pattern, one-half inch. First "tin" the surface to be "built up." Then place a wooden frame around that part of the pattern, so that its upper edge is in line with the desired finished surface. Then melt in with the copper, enough aluminum solder to fill the frame "heaping full." After rubbing the copper over the bottom and around the corners, to be certain that the solder is melted into the "tinned" surface below, when the solder cools to just the right temperature, "strike off" by "patting" with a block of wood, using the top of the wooden frame as a guide. Sometimes the "striking off" can be better done with a piece of smooth steel, like a scraper.

Fillets may be "wiped" in corners with a common waxing iron with nearly as much ease as wax fillets. The corner, after being "tinned," has a little solder run in, and immediately followed by the waxing iron, which if done at the proper moment, presses the solder into shape, leaving it as smooth as glass, and requiring no further finishing.

Sometimes additions may be more easily cast on than soldered and swept off. In this case the addition may be put upon the pattern in wood, wax, or in any convenient way and the pattern rammed up. After the pattern is drawn and the addition removed, the proper surface is tinned and the pattern replaced in the mold. After the mold is closed the addition is cast on by pouring in melted aluminum solder at a high temperature. Gates which have been broken off are sometimes replaced in this way.

* * *

SOME SIMPLE RED TAPE.

E. H. FISH.

Some time ago I was forced by circumstances to attempt to do about three men's work at the head of a small machine shop, covering a range from office boy to manager, by way of draftsman and superintendent. Some of the red tape with which I tied things up by way of lessening my own work may interest others who have to make every minute count.

I found at the start that the patterns had a systematic arrangement only in the head of a certain helper and that he was drawing about $150.00 extra a year for this knowledge. At 5 per cent. this made his system worth $3,000, which seemed a little high.

I found that we were building seven sizes of one machine, each designed with very little regard to the others. I began with this machine, and I assigned two hundred numbers to each size when one hundred would have covered the number of patterns for each at the start. Each piece was assigned a number from one up and the second size had this number with a two before it, and so on. That is, if the leg on the smallest size was numbered 56, then the leg on the next size would be No. 256, on the next No. 456, and so on.

This pattern list was blue-printed and a copy of it sent to the foundry, another copy to the machine shop foreman and another used by the pattern-maker and myself. On all drawings the numbers of the patterns were printed in red ink right on the part itself, often across the cross-sectioning. Red ink gives a line on a blueprint of such different character from black that we never experienced any trouble in picking out these numbers and distinguishing them from the dimension figures.

All patterns were stamped with their numbers with broad-faced stamps as carefully as possible, to get the numbers where the patternmakers would not slick them out. If a pattern was found to be used for two sizes of the machine, it was numbered at random with either size, as it happened, and the same number put on the pattern list under both sizes.

LATHE.	No. Pat.	No. on Hand.	No. to Get.	Pat. Found.	Ord.	Cast. Come.
Head	936	2	4	V	2/12	2 + 1
" Shoe	937	0	6	V	2/12	1 + 2 + 3 −
L. Face Plate	938	1	5	V	2/12	1 + 1
S. " "	939	2	4	V	2/12	2 + 2 −
T.G. " "						
" Ring						
Ex. Face Plate						
Face Gear	942	0	6			
Lock Nut						
Cone	944	0	6			1 +
Cone Gear	945	2	4	V	2/16	
F. Cap						
B. "						
F. Box						
B "						

Fig. 1. Blank used in Keeping Track of Castings in Foundry.

For example, if in a pattern list I found numbers as follows: 423, 424, 625, 426, etc., I would know that No. 625 was used on this machine and on the next larger size and that the pattern was to be found with those of the next larger size.

After the patterns were numbered, they were arranged each size by itself on the foundry shelves, and signs put up showing the size of the machine and the numbers between which the

patterns ran. It was easy after that to order castings over the telephone by number and be sure of getting what we wanted, and we could also be pretty sure that patterns would be returned to their proper shelves.

To keep track of the number of parts running through the foundry, we used the form shown in Fig. 1, this being printed on long strips and cut up to suit our convenience. This has a column in which to place the pattern number. Then a column for the number on hand, which should show from the previous list used for the same size machine, but which we always verified by actual count, including finished or partly finished work. Knowing the number wanted for a lot gave us the number to get, placed in the third column. When running through lots smaller than a dozen, we usually ordered in all the small parts for a dozen and ran them through together, keeping them over the next lot. Then checking off under the column marked "Pat. found," indicated that the pattern was at the foundry. A date mark under "Ord." showed that it was ordered.

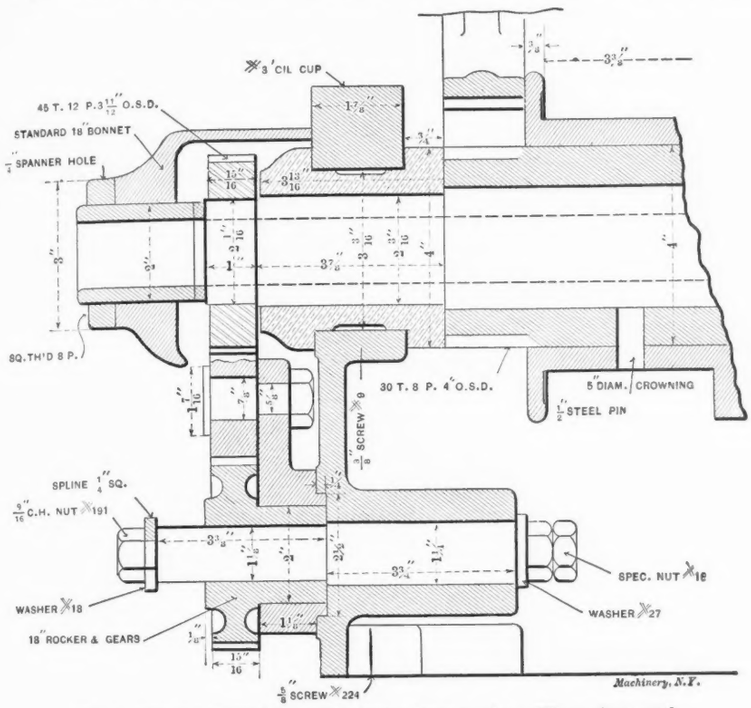


Fig. 2. Part of a General Drawing showing large number of Dimensions used.

As fast as castings came in, we checked them off in the last column. Whenever we went to the foundry, we took these lists along and "punched" them up to get out the missing parts.

This system enabled us to counteract two evils. Where a surplus supply of castings is readily available, and especially in a small shop where no rough store room is maintained, if a workman makes a mistake and spoils a piece, he is apt to throw it away and put another one through without letting the foreman know of it.

It is my opinion that it is cheaper in the long run to let spoiled work drop out of the lot as it goes along and have some all-around man make up missing parts, if necessary, one at a time. Usually we had a supply of all small parts, which are the only ones often spoiled, on hand all finished, but we found it very expensive to let a half-machinist try to make parts to replace spoiled ones as he went along.

The other evil referred to above is the over-making of easy castings in the foundry. An order for a dozen castings in the average foundry means the receipt of from ten to fifteen castings, according to the ease with which they are made relative to their weight.

When they knew in this way that we kept track of what they were doing and occasionally had a few come back, they kept within bounds in good shape. Such an accumulation of parts might do no harm if we never changed patterns, but where time is apt to change anything, it is not well to have much surplus stock coming in without our knowledge.

The next thing to claim attention was the drawings. What we had were only fit for use as amended. The amendments were in a former foreman's head, and therefore unavailable. A set of drawings for each size had to be gotten out in a rush. There was no time to think of detail drawings except where absolutely necessary. This settled down to a set of spindle forging drawings and some pieces that were to be made outside. This, at the time, was a matter of necessity. Now if I had it to do over again, I should do the same thing, no matter how much time I had at my command. Detail drawings are unsatisfactory to both workman and foreman until they become familiar enough with the machine being built, so that they know just where every piece goes and how it must be fitted together. To my mind, detail drawings and jigs go together and neither should be gotten out till the machine is a standard article to be made in large numbers.

So I made general drawings, using cross-sections very freely and a liberal supply of dimensions. I remember one 17-inch by 22-inch drawing with over 250 dimensions on it. Drilled holes and tapped holes were indicated by a center line, the size, and where necessary, the depth being indicated on a line drawn off at any convenient angle. Bolts, screws, nuts, washers, etc., were indicated in this way also. (See Fig. 2.) Keys, threads in section, pins, etc., were shown the same way. No pitches of threads were shown except for special taps, as nothing but U. S. S. taps were allowed where they could be used.

The reference numbers on Fig. 2 refer to a bolt list shown in Fig. 3. This list covers all small parts kept in the tool room. In this bolt list only those parts which were special were drawn out. All others had their commercial designation only.

Any reference on a drawing referring to "5/8 screw No. 19," called for the screw there shown. The size was given on the drawing so that it was unnecessary for the workmen to get a sample screw before drilling and tapping the hole for it. Screws were only taken from the tool room by men who were putting things together.

One set of blue prints from this list was given to the screw shop where we got our work done, and a set kept in the tool room.

Handles, hand cranks and hand wheels were next attended to. A little study showed that we could get along with about

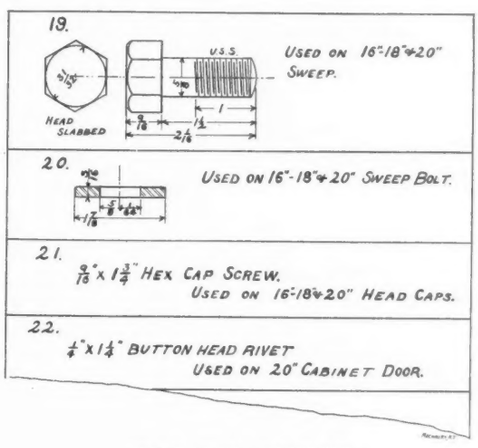


Fig. 3. Section of Bolt List.

half the number of different sizes that had been used. Those that we could not dispense with were drawn out as a regular drawing by themselves and numbered 1H, 2H, etc., at random. Reference to these numbers was all that was necessary on the drawings of the machines. Woodruff keys were used wherever possible and designated only by number. As we used only

three sizes, the men came to know their widths and could slot the pulleys or gears without looking them up. Ordinary straight keys were all square and were indicated by simply printing their size where it would readily show on the drawing. Keys with a tit on the end to keep them from having an end motion we found it better to draw out in full.

A cutting off list completed the regular drawings. This list gave the names of pieces and had a series of columns, one for each size machine, in which were given the diameter and length of stock wanted for each piece. Stock was furnished the men all cut to length and they had usually both the drawings and the pieces into which their work was to fit.

A list of the reamers and taps which we had in the tool room was always at my elbow and was constantly consulted to see that we could build whatever was designed. Drawings were all numbered in consecutive order for each size of sheet. As we only used two sizes, 17 x 22 and 11 x 17 (very few of the latter), no difficulty was experienced in distinguishing them without numbering or lettering the sizes. Everything was card indexed under its title and the cards were arranged, each size machine by itself. The parts of the machine were kept roughly in order from one end of the machine to the other. The foreman had a complete set of blue prints and a duplicate card index.

As drawings became obsolete, they were marked so and new drawings indexed. The foreman's discarded blue prints were taken away from him and his index card for that sheet also removed so that the foreman had only live drawings.

Patterns and drawings for odds and ends of jobs were only kept so long as we were sure there would be use for them. Special patterns were made over as often as there was a change and much work was done from freehand ink sketches. Attachments for standard machines were treated, however, as permanent work and were usually needed later.

REPAIRING A 400-TON HYDRAULIC PRESS.

FRANK M. DAVIS.

During the nine years I was assistant shop superintendent at the E. P. Allis works we had many interesting problems to solve in order to do the different jobs that came along. One which I think would interest your readers was the repair of a 400-ton hydraulic press, and I think that, in a certain sense, the circumstances connected therewith are as interesting as the repair:

The Carnegie Steel Company had a repair job in the shop in the shape of parts belonging to a large blooming engine. The old engine was running, and, although the parts showed some signs of giving out, there seemed to be no urgent need of the new ones. The new parts could not be finished until some details were received from the Carnegie Company; but we had started the job in the shop and were progressing nicely when the Allis Company received a telegram that the blooming engine had broken down and that the Carnegie Company must have the repairs at the earliest possible date. The repair parts consisted of large steel gears about 7 feet in diameter and about 3 feet face, the rims of which were cast steel and were shrunk on to cast steel centers. The gears were pressed upon two shafts 28 inches in diameter, one of which was the engine shaft and the other the jack-shaft.

Mr. Church, the shop superintendent, was on a vacation and I was doing the best I could to keep things moving. We were handicapped a little by having a new foreman in the

Frank M. Davis was born in Goshen, Mass., 1865. He learned the patternmaking trade, and then took up machine and foundry work. He showed executive ability at an early age, having been foreman and superintendent of shops since he was twenty-one. Mr. Davis was assistant superintendent of the E. P. Allis Co. for nine years, and it was while directing the heavy engine work in these shops that he became impressed with the need for large micrometer calipers of light construction for making accurate measurements. He is now in business for himself as one of the partners of Frank M. Davis & Co., making the Davis tubular frame micrometers and other specialties.

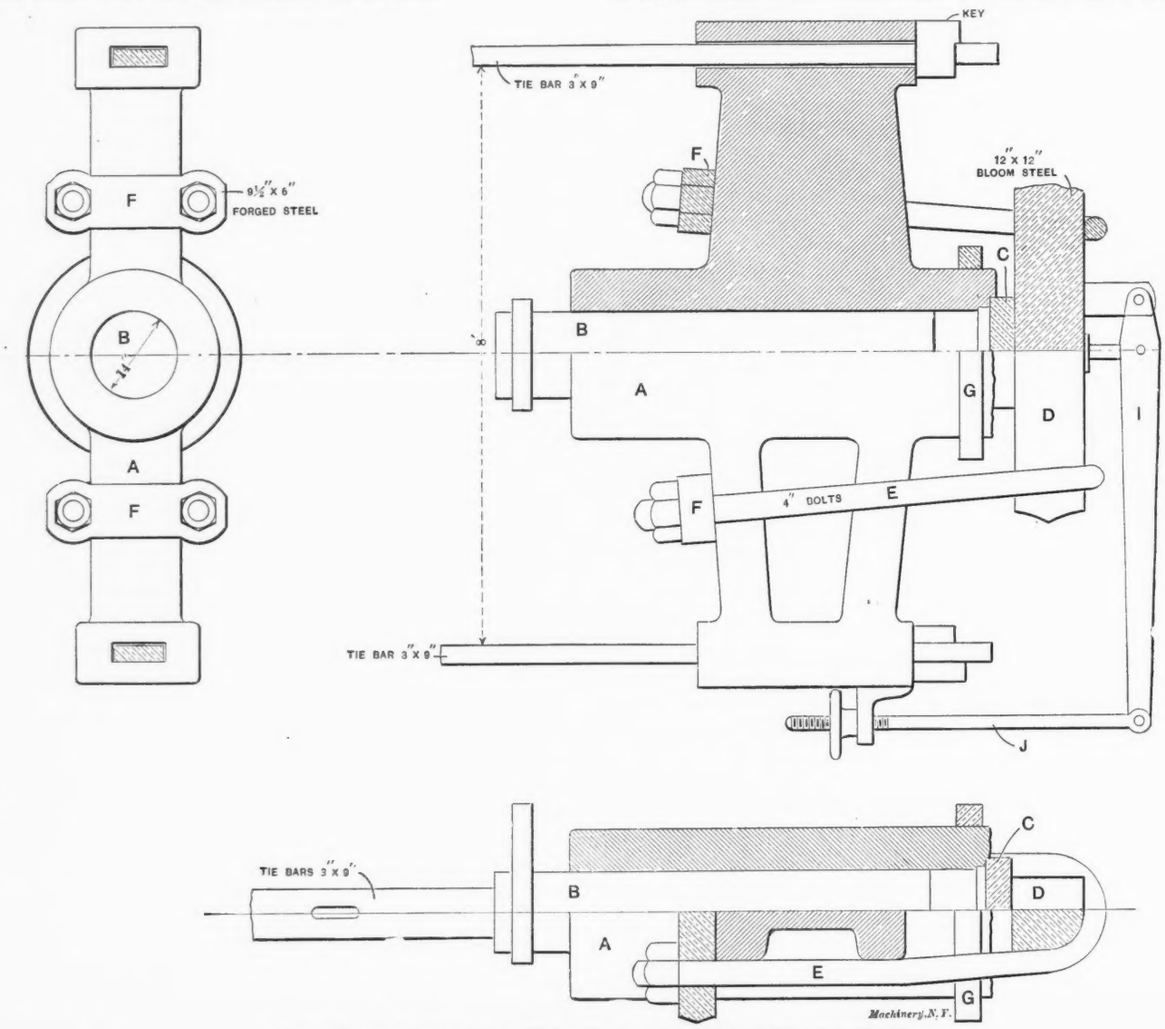


Fig. 1. Showing how a 400-ton Hydraulic Press was given an Emergency Repair.

shop where the press-work was being done and by our old pressman being away at the time. The Carnegie Steel Company had sent inspectors to keep them posted as to the progress made, and I had promised them that the work would be done on Friday. I instructed the foreman to notify me when they were ready to press the work together as I was

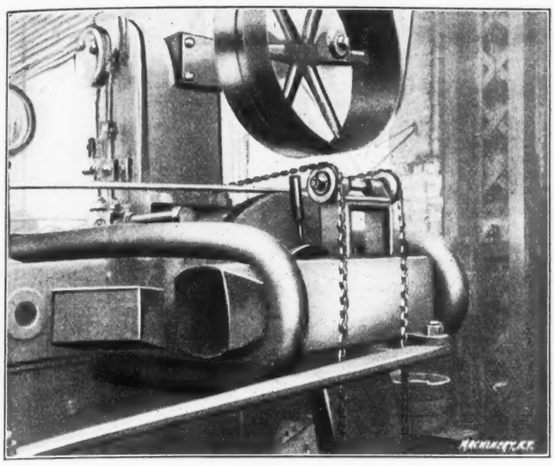


Fig. 2. Rear View of Press, showing Repair.

very busy attending to some other matters. He, being a good man and wishing to push the work as far as possible, thought he would get the pressing started and then notify me, thus saving my time; but, when the pressing was started, the pressure began to run up rapidly, reaching the 400-ton mark before the gears were forced home. Something had to be done quickly and he decided to help the press along; so swung a large ram on the crane, got plenty of men behind it, and began to drive the gear. Meanwhile the small high-pressure pump was at work and the pressure was going up; all at once the back end of the ram cylinder broke off, striking a large lathe and demolishing the change gear, etc. Then it did not look much as though we would ship the job on Friday as this was Wednesday about 5 P. M.

The foreman came to my office and I knew something serious had happened by the expression of his face. "Well, we are up against it; the press is broken." I replied that if this was so we must fix it; the Carnegie job must go as the mill is shut down. A new press cylinder was out of the question, but, by hard work, we managed to get the press together and by 9 o'clock Friday night the gears were all pressed in place, keys driven home, and the job ready for shipping. Extra heavy cars were required to handle the shafts which arrived about 11 o'clock Friday night and the job was loaded on these cars and taken to Pittsburg by special engine. In view of the fact that the press is in constant use and gives no trouble whatever, the repair may be considered of considerable interest, especially when we remember that in a 400-ton press having a ram 14 inches in diameter, the area of which is 153.9 square inches, the pressure may become as high as 5,200 pounds per square inch. Water gets very thin at this pressure.

Referring to the cuts, cylinder *A* was formerly a casting with the back head cast on. It broke off at the ragged line shown in Fig. 3, and I had a seat bored and faced off so as to make the counterbore width one inch all round. A soft steel disk or plug *C* was turned to fit the seat tight and a gasket of copper was placed between the steel plug and the cylinder. *D* is a 12-inch square bloom which we had forged to fit the U-bolts *E* where they went around the bloom. These bolts are 4 inches in diameter and the straps *F* at the opposite end from the bloom are smooth forged 6 x 9½ inches, the holes being punched in the blacksmith shop.

The job was assembled with the press placed on end. Plug *C* and the copper gasket were put in place, and the square bloom bar *D* was placed on top of same and then the U-bolts were shrunk in place. The cylinder was reinforced at the broken end by shrinking around it a steel band *G* 3½ inches square. This was done in order to make sure that there should be no leakage through cracks that might have been developed when the end broke off. In order to let the water out of the cylinder, when the pressure was relieved a hole was drilled through the plug *C* on the bottom side of the cylinder, as shown in Fig. 3, and another was drilled from the side of the plug to intersect it, in which was screwed a drain-pipe to carry the water into the reservoir. The valve was made of a piece of Tobin bronze which was guided by a strap *K* bolted on to the bloom *D*. To this a lever was attached to which was connected the rod *J*, having at the opposite end a coarse pitch screw and a hand-wheel with which to force the valve against the seat. When the press was ready for operation, in place of grinding the valve in, we simply took a heavy sledge and drove the valve home, using the large lever to assist in forcing it against the seat. Notwithstanding this heroic treatment it proved to be tight. It

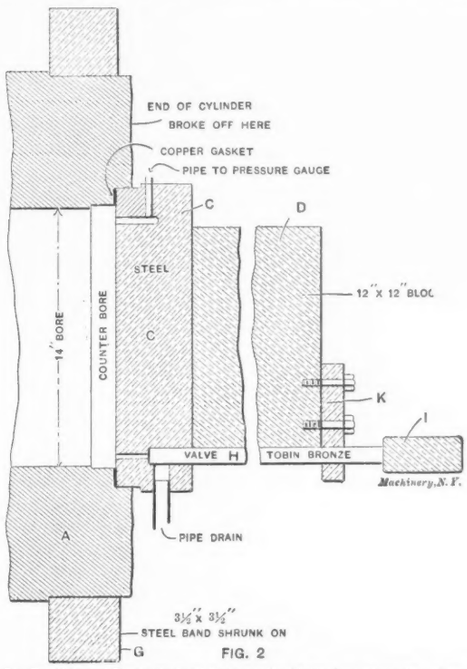


Fig. 3. Section of Rear End of Hydraulic Cylinder, showing how the Valve and Gage Connections were Made.

may be thought strange that a 12-inch square bloom was used behind the plug *C*, but it must be remembered that the repair parts had to be strong enough to stand an extreme pressure of 400 tons without springing. Any perceptible spring in the bloom or the U-bolts would have caused a leak sufficient to have destroyed the pressure.

* * *

MAKING INSERTED CUTTERS IN ARMSTRONG BROS. SHOP

One of the interesting corners of Armstrong Brothers' shop in Chicago, the makers of the well-known Armstrong lathe and planer tools, is that in which the self-hardening steel cutters are made. Bars of unannealed, self-hardening steel are cut into lengths of say four inches, using the Armstrong friction disk machine for cutting off. The rods, however, are not cut off at one pass of the wheel in the usual manner of cutting off, but are nicked on all four sides and are then broken apart. The nicking is done rapidly with the friction saw, which is a thin steel disk only 1/32 inch thick. The depth of the cut is about one-quarter the thickness of the bar, and a gage is provided which permits the operator to turn the bar and cut the nicks around it all in the same plane. By nicking the bar all around in the manner described, the work is made easier on the friction saw and a better shaped end on the cutter blanks is assured.

The cutters are ground to shape in the same department and are heated for hardening simultaneously with the grinding operation. The operator forces the point of the cutter against the emery wheel with sufficient pressure to make it red hot, and finishes the point to the proper shape at this temperature. He then throws it into a box underneath an air blast, the result being that the self-hardening steel cools and hardens the same as if it had been heated in a forge and cooled in an air blast in the usual manner.

COUNTERBALANCING AN OSCILLATING ENGINE.

The New Britain Machine Co., New Britain, Conn., are known to readers of MACHINERY as makers of a line of stock racks, bench fittings, trays, shelving, etc., which they style "Shop Furniture." The original product of this company, however, the manufacture of which still forms an important part of their business, was the Case steam engine. This engine runs at very high speed and accordingly is small and compact for the amount of power developed. In order to secure smooth running at these high speeds, however, it was necessary to give careful attention to the question of balancing. The cut-and-try method of determining the proper size and location of the balance weight for different sizes of engines was the one originally adopted, but the results obtained were found to tally so closely with the calculated results by what is known as Beck's counterbalancing formula, that the latter is now depended upon entirely.

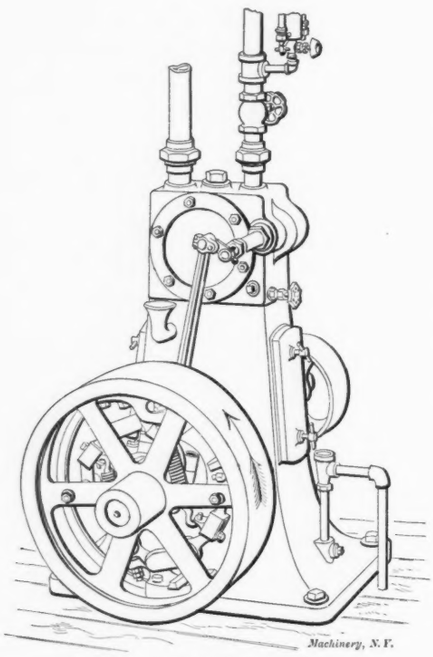


Fig. 1. Case Automatic Engine.

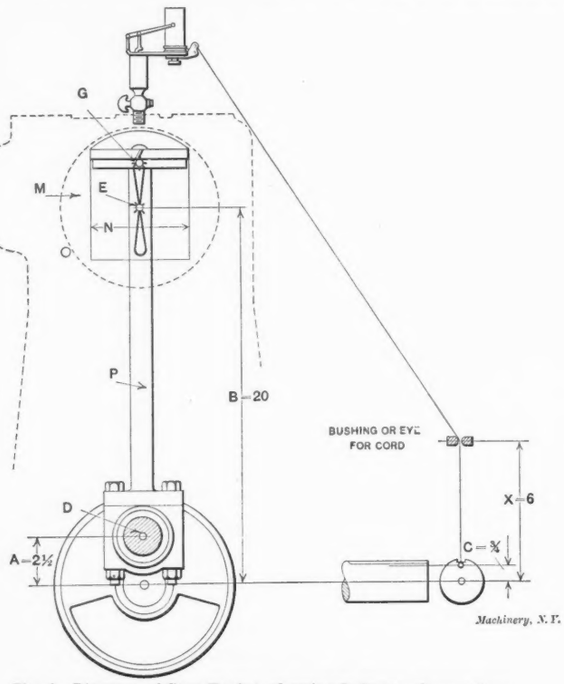


Fig. 2. Diagram of Case Engine, showing Indicator Connections

Before explaining the experimental work done in investigating the subject of counterbalancing, it will be necessary to explain the peculiarities in the design of the Case engine, although they are familiar to many, and perhaps most of those who will read this. The Case engine has no connecting rod, but, instead, the piston rod carries the crank pin bearing and the cylinder is contained in a casting whose outward form is cylindrical, allowing the cylinder and piston rod to oscillate as the crank rotates. It is an improved form of oscillating engine, eliminating, however, the usual trunnions, and the trouble incident to maintaining steam-tight joints at these points. In Fig. 1 is an outline drawing of the engine showing its exterior appearance, and in Fig. 2 is a diagram indicating the construction of the main working parts and showing also the method of connecting up an indicator for testing the engine. The cylinder casting is at *M* and the bore of the cylinder is indicated by *N*; the piston rod is at *P*, carrying the piston on the upper end and the crank pin bearing at its lower end. In an engine of the ordinary type the path of the piston is forward and back in a straight line, and the piston stops twice during each revolution, at the end of the stroke, when its direction of motion is reversed. In the Case engine, the path of a point *G* on the piston is in the form of an elongated figure 8 and the piston does not come to a dead stop at either end of the stroke. This contributes to smooth action and enables the engine to turn over centers without a flywheel, if desired, and with the light moving parts of the engine permits high speed with small vibration.

In preparing for the balancing tests, provision was made for driving the engine under experiment from an external source of power, in order that the vibrations of the engine frame should not be checked or eliminated by steam pipe connections, such as would be necessary if it were driven under its own steam. In Fig. 3 the engine at the right is the one being experimented with and it is driven by belt from the engine at the left. The experimental engine is mounted on a spring board for the purpose of magnifying the vibrations at the top of the frame in all directions. Provision was then made for taking continuous diagrams showing the extent and frequency of these vibrations. The diagram is traced on a

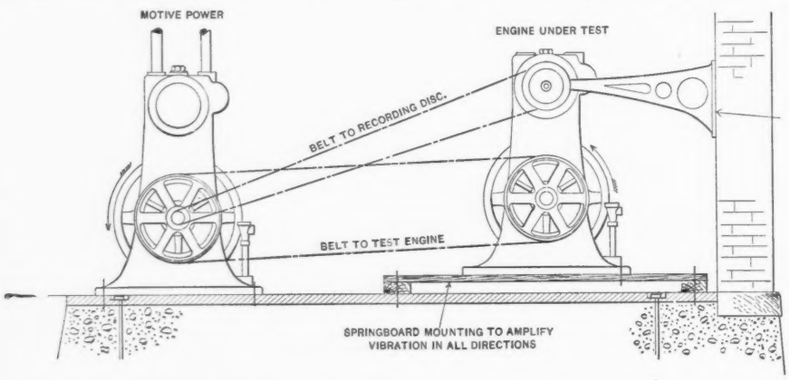

MOTIVE POWER
ENGINE UNDER TEST
BELT TO RECORDING DISC.
BELT TO TEST ENGINE
SPRINGBOARD MOUNTING TO AMPLIFY VIBRATION IN ALL DIRECTIONS

Fig. 3. Engine Mounted for Counterbalance Testing.

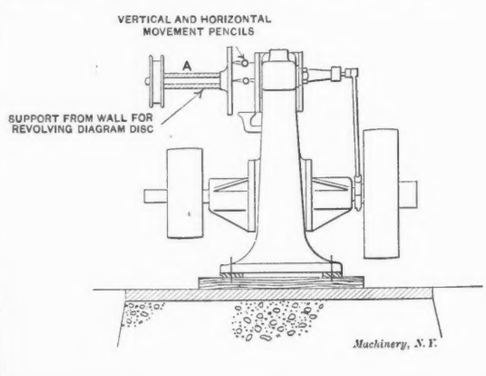


Fig. 4. Showing Rotating Disc for Recording Vibrations.

circular sheet of paper mounted on a rotating disk by two pencils attached to the upper portion of the engine frame. The rotating disk is on one end of a short shaft turning in a bearing at the end of a bracket bolted to the wall near the experimental engine. The bracket is represented in Fig. 3 and a section of the bearing at *A* in Fig. 4. On the other end of the shaft is a pulley driven by belt from the driving engine.

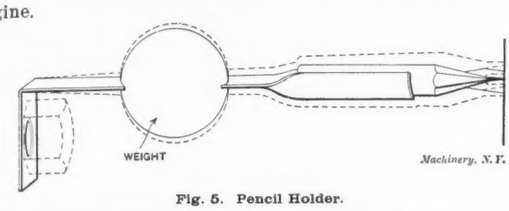


Fig. 5. Pencil Holder.

The two pencils used in tracing the diagram are each mounted in a weighted spring holder bolted to the engine frame, as shown in Fig. 4. One of these holders appears in Fig. 5 and it will be noted that it is made of a piece of flat metal, which allows of vibration in one direction only. By using two such holders, one so located as to vibrate in a vertical direction and the other in a horizontal direction, and by locating the points of the pencils so that they bear against

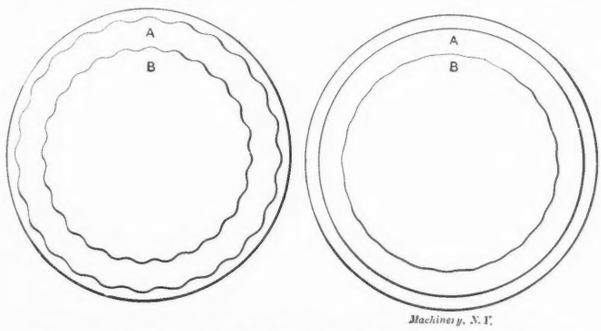


Fig. 6. Diagrams showing Effects of Vertical and Horizontal Vibrations.

the rotating disk, two circular diagrams may be traced, indicating, respectively, the horizontal and vertical vibrations of the engine.

In Fig. 6 are two cards, reduced in size, taken by means of this apparatus. The one at the left, having waving lines, indicates that too little counterweight was used, causing excessive vibration both vertically and horizontally. Additions to the counterweight reduced the vibration to practically nothing, as shown in the second card at the right. These two

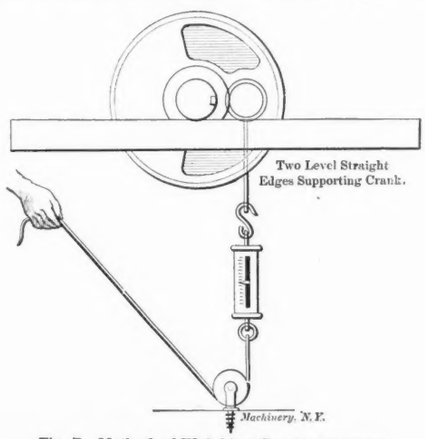


Fig. 7. Method of Weighing Counterbalances.

cards were taken from a 13-horse-power Case engine running at 560 revolutions per minute, record *A* showing the vertical vibrations and record *B* the horizontal vibrations. As a result of these experiments it was determined that the Beck counterbalancing formula gave figures for the counterweight that were close enough for practical purposes. This formula is as follows:

$$W = \frac{F\,m}{M}$$

where W = weight of counterweight
m = weight of reciprocating mass
M = weight of non-moving mass
F = initial accelerating force.
$= \overline{\text{R. P. M}}^{2} \times$ radius in feet $\times$ .000341 $\times$ reciprocating mass.

Fig. 7 shows how the weight of the counterbalance is determined in applying this formula.

In further explanation of Fig. 2, which shows the indicator connections for the engine, it will be noted that distance *B* from the center of piston travel to the center of the shaft is

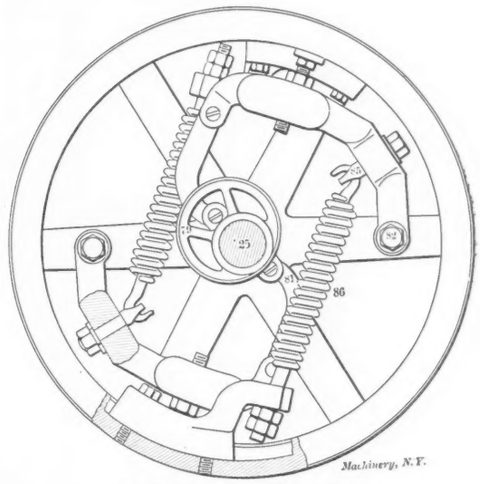


Fig. 8. Governor of Case Engine.

constant, and accordingly, a bushing or eye through which the indicator cord passes is located at a fixed distance, *X*, from the center of the shaft. The cord coming from the indicator passes through this bushing and is attached to a pin in the end of the shaft, located a distance, *C*, from the center of the shaft, according to the following proportion:

$$A : B :: C : x.$$

In the above, A = length of the crank, and C = corresponding length of the crank operating the indicator cord. The ar-

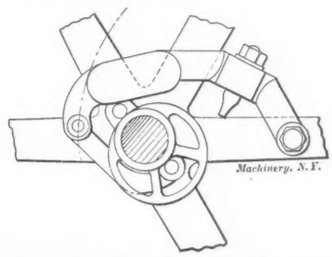


Fig. 9. Position of Eccentric when Shifted through 180 degrees.

rangement, therefore, forms a connecting rod of that part of the cord below the bushing, which is of variable length proportionate to the constantly changing length of the piston-connecting rod from *D* to *E*. This rule for the indicator connection holds for any type of oscillating engine.

Another feature of interest in connection with this engine is the centrifugal governor, which is so designed as to allow a movement of the eccentric through an angle of 180 degrees, or a full half revolution. The oscillation of the cylinder controls the admission of steam, and the shaft governor, which operates the rotary valve, controls the cut-off. In engines where both the cut-off and the point of admission are controlled by the governor, it is necessary to shift the eccentric across the shaft as well as to rotate it about the shaft in order to keep the lead constant. Where the governor controls the cut-off alone, however, it is only necessary to rotate the eccentric about the shaft, since the point of admission is controlled by other means. In this latter system, full port opening is secured at all points of the cut-off. In the Case governor the eccentric rotates about the shaft and regulates the point of cut-off from zero to practically full stroke. This wide range of cut-off is accomplished by rotating the eccentric through a full half revolution, as stated above. To do this

by a crank and connecting links, without causing the cranks to go on a dead center at either extremity of their travel, advantage is taken of the curved paths followed by the extremity of the weight arm and the eccentric. Fig. 8 shows the eccentric in one extreme position with the weight arms out to the furthest extent; while Fig. 9 shows the eccentric moved through 180 degrees with the weight arms in their extreme inner positions.

* * *

A NOVEL MECHANICAL MOVEMENT.

We have received sketches from a contributor, which show two different methods for raising the sash in green houses. The sketches are reproduced in Figs. 1 and 2 and it is stated that both devices are in use, but that the one in Fig. 2 seems to work easier, although it gives a slower motion to the sash. Point marked *S* is the shaft, which runs lengthwise of the green house, and the lever connections with the different windows open and close them when the shaft is turned. Fig. 1 is

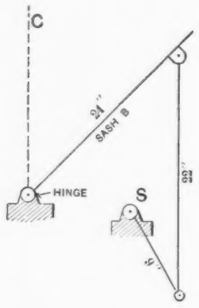


Fig. 1.

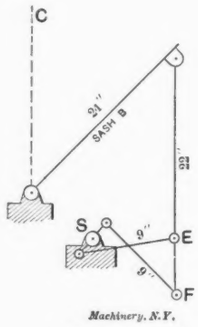


Fig. 2.

a simple crank and pitman movement, and in Fig. 2 there are two cast-iron arms keyed to the shaft, to the ends of which two 9-inch links are attached. These links cross as shown, and at their outer ends are attached to a third link which extends from *F* to the point of attachment at the sash *B*. When the sash is opened it takes the position shown by the dotted line at *C*. Several questions are asked about this mechanism, which we will attempt to answer in what follows, explaining the movement somewhat in detail, but without attempting a mathematical demonstration.

This mechanism is a modification of what is known as Tchebicheff's Approximate Parallel Motion, shown in Fig. 3. The motion consists of four links, one of which, *D B*, is stationary and forms the base of the apparatus. The opposite link, *A C*, is connected to the stationary link by the two crossed links of equal length, *A B* and *C D*. The central point *O* of the link *A C* will move in approximately a straight line

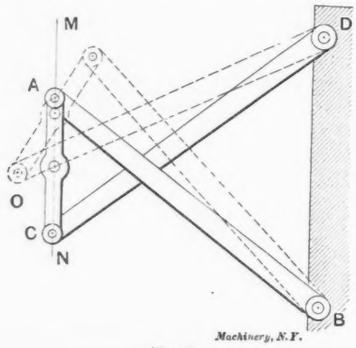


Fig. 3.

when the link *A C* travels up or down, provided the several links are proportioned correctly. Calling the length of link *D B* equal to 4, than *A B* and *C D* should each be equal to 5 and *A C* equal to 2. The dotted lines in Fig. 3 show the positions of the parts when link *A C* is raised a short distance.

Fig. 4 shows the straight-line motion in a modified form, such as might be used to raise the sash of green houses or for raising any other weight. The change in the mechanism consists simply in making *D B* a movable link and pivoting point *O* in a stationary bearing, point *O* corresponding to the center of shaft *S* in Fig. 2. The parts of the mechanism are lettered the same in Figs. 3 and 4. The dotted lines in Fig. 4 show the two extreme positions, up and down, into which it is possible to bring the link *D B* by rotating the shaft. In the extreme upper position the different pivots are located at points *A'*, *C'*, *D'*, and *B'*, and in the extreme lower position at *A"*, *C"*, *D"* and *B"*. It will be noted that for half a turn of the shaft, or a movement through 180 degrees, link *D B* will have traveled a distance *L*. In order to compare this with the simple crank movement of Fig. 1, the upper diagram, Fig. 5, has been drawn, showing that to effect a movement *L*, equal to the distance *L* in Fig. 4, the lever will have moved through an angle of but slightly more than 45 degrees, assuming length of lever to be 9 inches. In other words, it has been necessary to rotate the shaft nearly four times as far in the mechanism of Fig. 4 as in the other case, to produce a given

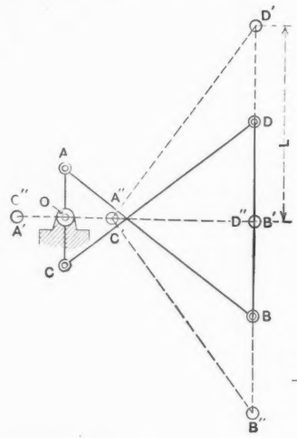


Fig. 4.

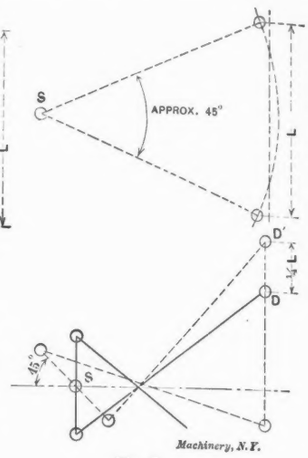


Fig. 5.

movement of the link; and neglecting friction loss, which would be more in the former than in the latter, the shaft in Fig. 4 should turn nearly four times as easily as the shaft in Fig. 1, and nearly four times as great a weight could be raised with the former as with the latter. The effect of the linkage of Fig. 4 is substantially the same as though the shaft *S*, in Fig. 1, were geared up to a crank on one side of the shaft, with two pinions in the ratio of 4 to 1, the larger pinion being on the lifting shaft and the smaller one on the crank shaft.

When this motion is used for raising the sash of a greenhouse, it is evident that the point of attachment to the sash does not move it in a straight line and hence the link *D B* does not remain in a vertical position. This makes no difference in the principle of its operation, however, since the mechanism will work equally as well whether a point on the link *D B* is guided in a straight line, or is compelled to travel in a curved path.

Another interesting point about this straight-line motion is that the velocity ratio between the shaft and the link *D B* at the outer end of the connecting links, is very nearly constant, as is shown in the lower diagram in Fig. 5. Here the shaft *S* is represented as having turned through 45 degrees, or ¼ the distance that it turned in Fig. 4, where the movement of the link *D B* was equal to a distance *L*, and it will be noted that the distance traveled by point *D* of the link in Fig. 5 is also practically ¼ *L*, showing the velocity ratio of the mechanism to be very nearly constant.

* * *

The zapote tree which grows in Mexico is remarkable for the extreme hardness of the wood when it has become thoroughly seasoned. U. S. Consul A. J. Lespinasse, at Tupam, Mexico, writes, that although zapote wood is easily worked when green, it is so hard when seasoned that only the finest-edged tools have any effect on its flint-like surface. Sharp-pointed nails can be driven into the wood only about an inch, and the fiber is so dense that the wood sinks rapidly in water and will remain immersed for years without being affected in the least. The chicle sap which exudes from the tree when tapped is very viscous when partially dried and is very adhesive; this property makes it very valuable for repairing broken articles and it is largely used as a cement for fastening leather tips to billiard cues, etc.

RESISTANCE OF JACKETED BULLETS WHEN FORCED THROUGH THE BORE OF 0.30 CALIBER RIFLE BARRELS.

The passage of a bullet through a rifle gun is by no means a simple action, but, on the contrary, is quite complex. The force generated by the burning powder is expended in overcoming the inertia of the bullet to motion in a direction parallel with the axis of the bore; in overcoming the inertia to gyration on its axis, and the friction of the bullet in the bore of the gun. The force required to accelerate the bullet and to give it the gyration required by the rate of twist of the rifling, may be calculated; but the resistance due to friction is an unknown quantity which is only determined by test.

Some experiments have been made at the Watertown Arsenal to determine the resistance of jacketed bullets when forced through the bores of .30-caliber rifle barrels. The tests were made with barrels having a twist of one turn in 10 inches, and one turn in 8 inches, respectively; and jacketed bullets were used having bearing surfaces ¼, ⅜, and ½ inch long respectively. The accompanying diagram, Fig. 1, shows the resistance curve of a steel-jacketed bullet when forced through the bore of a barrel having a twist of one turn in 10 inches, the bullet having a bearing surface ¼ inch long. The bullet was pushed slowly through the bore by a hydraulic piston, and the velocity was a variable factor until a distance of about 11 inches had been traveled, after which it was uniformly about 0.083 foot per minute. The highest resistance recorded was 1,048 pounds, which was developed 0.55 inch from the start. The average resistance was about 650 pounds.

Fig. 2 shows the curve resistance of a steel-jacketed bullet having a bearing ⅜ inch long. It will be observed that the velocity with which the bullet was forced through the bore was again quite variable, averaging about 0.07 foot per minute. The highest resistance was 1,008 pounds, which was developed 2½ inches from the start; it averaged about 880 pounds.

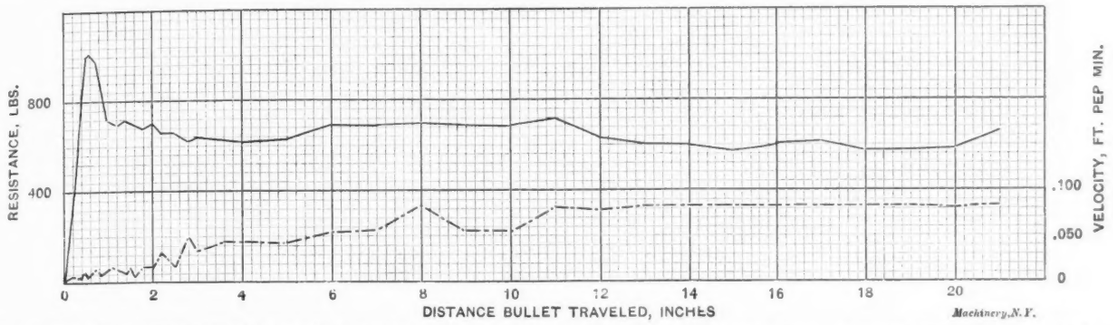


Fig. 1. Curve of Resistance of Steel Jacketed Bullet when Forced through the Bore of a 0.30 Caliber Rifle Barrel. Bullet with Bearing Surface 1-4 inch long.

Fig. 3 is the resistance curve made with a barrel having a twist of one turn in 10 inches, but the bullet had a bearing ½ inch long. The average rate of velocity employed in forcing the bullet through the bore was about 0.07 foot per minute. The resistance averaged about 920 pounds, the highest resistance being 1,096 pounds, 11 inches from the starting point, when the velocity was 0.083 inch per minute.

When a bullet having ¼ inch bearing was forced through the barrel at the rate of one foot per minute, the barrel was perceptibly warmed, and the maximum resistance reached 1,800 pounds, dropping to 1,450 pounds until the bullet had traveled nearly through. The resistance of a bullet having a bearing of ¼ inch in a barrel having a twist of one turn in 8 inches reached a maximum of 956 pounds 0.65 inch from the start, and averaged about 720 pounds for the travel of 21 inches; with a bullet having a bearing surface ⅜ inch long the maximum pressure reached 1,295 pounds 11.5 inches from the start, and the pressure averaged about 1,120 pounds; and a bullet having a bearing surface ½ inch long gave a maximum resistance of 1,198 pounds 15 inches from the start, the average resistance being about 1,080 pounds. Diagrams are not shown for the tests mentioned in the last paragraph.

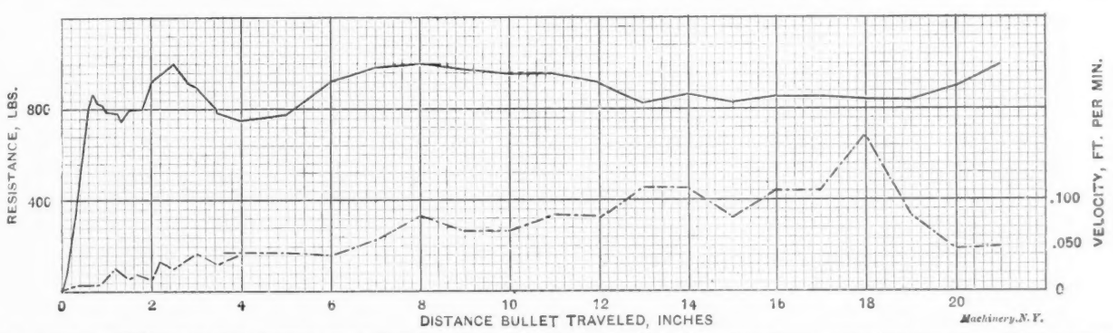


Fig. 2. Curve of Resistance of Steel Jacketed Bullet when Forced through the Bore of a 0.30 Caliber Rifle Barrel. Bullet with Bearing Surface 3-8 inch long.

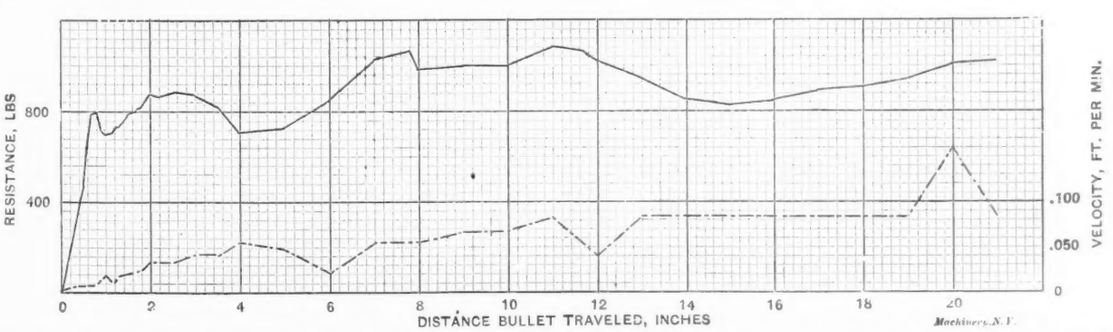


Fig. 3. Curve of Resistance of Steel Jacketed Bullet when Forced through the Bore of a 0.30 Caliber Rifle Barrel. Bullet with Bearing Surface 1-2 inch long.

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THE LIMIT IN PUMPING MACHINERY.

It is to be expected that the attention now being given to centrifugal pumping machinery, especially to the multi-stage type for delivering comparatively small bodies of water against high heads, may lead to the perfection of larger sizes of such machinery. The need for this is demonstrated in the recent installation of a Leavitt 72,000,000-gallon sewage pumping engine at Boston. This engine was built by the I. P. Morris Co., Philadelphia, Pa., who have constructed much of the Leavitt machinery. Certain parts of this engine are so massive that it was impossible to ship them by rail and they were carried around by water on a 1,500-ton barge. Some of the weights of the parts are as follows: Beams and pins, 50,000 pounds; low-pressure cylinder, 40,000 pounds; beam pedestal bed plate, 34,000 pounds; plunger, 30,000 pounds; upper pump chamber, 26,000 pounds; crank shaft, 23,000 pounds, etc. The total weight of the engine and pump is about 1,700,000 pounds. There are two single-acting pump plungers 60 inches in diameter and having 120 inches stroke.

Pumping engines of this type represent the extreme limit in expensive construction for the work that has to be done. The number of dollars required to pay for each horse-power of engine is something extraordinary. Not only is no expense spared to produce a machine that will operate on low steam consumption, but the mere cost of cast iron and steel is a large item, as shown by the weights given above. The Boston engine runs at 17 revolutions a minute only, and at such a speed it must necessarily be large and massive.

Centrifugal pumps, on the other hand, are compact, simple, comparatively inexpensive and run at high speed. The objection to them for drainage and water service, where large volumes of water are handled, is their inefficiency. The losses in smaller pumps of this type, however, have been gradually diminished during the past few years, and it is reasonable to suppose that corresponding improvements will be made in the larger ones. A number of years ago the New Orleans Drainage Commission installed several very large centrifugal pumps, which is the most important application of this type of machinery that has yet been made. One of these pumps has a capacity of over 300 cubic feet per second. The discharge outlet is 6 feet in diameter, and the pump is driven by a 500 horse power motor. The efficiency of the pump was found under test to be 74 per cent. This may be compared with the Leavitt engine, installed in Boston at the Main Drainage Works about twenty years ago. The efficiency of this engine and its pumps, taking into account both the losses in the mechanism and the losses through slip, was about 80 per cent. It is probable that in some recent engines this efficiency might be increased to perhaps 85 per cent., although this is doubtful. If we consider the mechanical or electrical losses of the motor required to drive a rotary pump like that at New Orleans, it is probable that the total efficiency would be reduced to about 70 per cent. There is thus much to be done before the centrifugal pump can compete in efficiency with the plunger type; but on the other hand, both the first cost and the expense for attendance are very much less. We believe that in the near future the performance of both from the commercial standpoint will be practically on a par.

* * *

EMERGENCY REPAIR JOBS.

A superintendent of a machine shop doing a wide variety of work, some of which is of an emergency nature, must be more than an ordinary mechanic if he is to succeed. He must possess the faculty of quickly deciding the best way of doing any job, and in great stress must often have the courage to do it in a way that might be considered unallowable ordinarily, but which serves the purpose in getting the desired result. The description of the 400-ton hydraulic press repair by Mr. Davis, on another page, is a good example of executive ability and is well worth reading for that feature alone, to say nothing of the information as regards the mechanical details. A mere mechanic, carefully trained to the nice ways of doing work, would be little less than horrified at the heroic way of fitting the Tobin bronze valve to its seat, *i. e.*, driving it in with a heavy sledge, but it is in such matters as this that the successful shop manager rises to the occasion and "gets there" while the other man perhaps would be lost in trying to follow the ordinary methods learned in the trade. In the building of machinery, as well as everything else in general, results are what are desired; but the trained mechanic is likely to think more of the conventional ways and means employed than of the ultimate purpose for which he is working. It is this condition of mind which is to be eliminated to a large degree when brought face to face with emergency work of the character discussed. The valve was required to be tight against its seat; it mattered not, so far as the press job was concerned, whether it was made tight by careful grinding of flour emery and the expending of hours of time, or whether it was driven home with a sledge. After the repair was made they could well afford to remove the valve and replace it with a new one, if need be, carefully fitted in the conventional manner. Its cost was insignificant compared with the heavy loss to some one that would have been caused by not getting the job done on time. To sum up, a mechanic should learn when it is possible and best to sacrifice small details in order that results may be accomplished; in other words to acquire a prospective judgment that shall enable him to accurately value things.

* * *

A mistake that is frequently made in gas engine design is to assume that the bolts through the connecting-rod basses have little or no work to do beyond merely holding the rod and crank-pin together, inasmuch as the ordinary type of gas engine is a single-acting machine and the rod is supposed to be always in compression. Such is not the case, however, since the force required to accelerate the piston on the ends of the stroke is always considerable, and with short connecting-rods and heavy pistons it may be, momentarily, equal to or even greater than the normal pressure due to the explosion. Moreover, when an engine is running without charge due to its momentum the piston is not cushioned as it is under working conditions. Hence the importance of proportioning such bolts so that they shall be strong enough to transmit the full power of the cylinder through the connecting-rod in tension as well as in compression.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH

A recent consular report from Nottingham, England, states that a Lancashire mechanic has invented a sewing machine which sews direct from two spools of thread, thus obviating the winding of bobbins and the threading of shuttles. The new machine is simple in construction and it is believed that the improvement will revolutionize sewing machine constructon.

The new Sherardizing process for galvanizing iron and steel which is being exploited in Great Britain is said to protect the metal from corrosion to a remarkable degree. Even after the apparent removal of all the zinc by cutting or filing, the abraded surface of the iron is still noncorrosive. This valuable property is attributed to the protective action of the zinc-iron alloy formed on the boundary line between the iron and zinc.

With the completion of both bores of the great Simplon tunnel through the Alps, through which trains will soon be running regularly between Brig in Switzerland and Iselle in Italy, comes the announcement that another Alpine tunnel is projected through the Bernese Alps from Frutigen to Raron. If this tunnel passes under the Lotschberg, as projected, it will be the longest in the world, having a length of 13.07 miles. The Simplon tunnel just completed is 12.26 miles; St. Gothard 9.31 miles; and Mount Cenis 7.98 miles. The estimated cost of the new tunnel is $12,376,000, but it is thought more likely that it will reach $16,000,000.

An interesting character sketch was recently published in the *English Mechanic* on Bertha Krupp, the so-called "millionaire girl gun-maker," which incidentally mentions a strange arrangement of the works; and that is that every gun, musket or other firearm that leaves the Krupp factory is tested in a vast tunnel. "Periodically the whole town of Essen, which is built over a maze of exhausted coal galleries, rocks and reverberates as the guns are fired. The crash within the tunnel is appalling, and the strongest men cower in terror when they first stand in the horrible place and hear the roaring of the guns in the depths." Notwithstanding these terrors it is alleged that Miss Krupp insisted on being present at a firing trial, such is her devotion to duty.

In a paper on "High-Speed Tool Steel," read by Mr. Arthur B. Corby before the Salford Science Students' Association, April 8, 1905, the author referred to the defective design of tool-rest found on most American lathes and said that in this regard the English type of tool is far ahead of the American. The support of the tool, especially when made of high-speed steel is of vital importance. High-speed steel more than any other seems to have a peculiar property of sharpening itself by the action of the work and the wear of the chips. Even when a tool has shown signs of failing it will pick up in a wonderful degree if held to the work; but if, when it begins to fail, the work can push it away at all, it will soon break down altogether. Hence the importance of supporting the tool in the most rigid manner possible.

The tunnel system of Chicago, which was built underground in two senses of the word—the work being carried on without the knowledge of the great majority of the citizens—was ostensibly projected at first as a system of electric wire conduits, but was afterwards extended to include a system of narrow-gage freight tracks. It is alleged that the system will aggregate 132 miles of electric railway underground when completed. Its purpose is to supplant the business of trucking in the streets, the plan being to have basement entrances into the large establishments having a great volume of freight to handle. The system seems an ideal one as it will eliminate a large part of the traffic with which business streets are ordinarily congested, and will be quicker and more reliable than the horse-drawn truck.

The Naxos-Union, Frankfort-on-Main, Germany, makers of emery wheels, have an interesting method of securing trade and at the same time getting an exact expression of a customer's wants in the matter of emery-wheel shapes. Sheets of gummed paper, perforated so as to make small rectangular sections similar to postage stamps, are sent out to prospective buyers. Each space carries a cross-section cut of an emery wheel type, with the dimensions left blank. The customer is expected to fill out the blank dimensions and paste the sticker to his letter. When this is done there can scarcely be any mistake in the type of wheel desired. If some equally as simple and effective method of securing an expression of the grade of wheel could be devised, it would greatly simplify the emery wheel problem for the manufacturer. Practically all users know what shape of wheel is best suited to their work, but many do not know the grade of grit that is most effective.

The Times Engineering Supplement says that in his recent series of lectures on "Flame," at the Royal Institution, Sir James Dewar illustrated in a striking form a fact which has long occupied the attention of scientists in relation to the energy expended in the production of light. The following figures show how utterly imperfect are the various lighting devices now employed on a basis of scientific efficiency:

	Percentage of Light.	Non-luminous Energy.
Candle	2	98
Oil	2	98
Coal gas	2	98
Incandescent lamp	3	97
Arc lamp	10	90
Magnesium lamp	15	85
Cuban firefly	99	1

Considerable interest has been aroused in the commissary department of the United States Army in the investigation of the so-called fireless cooking stoves which have been used many years in some European countries. The fireless cooking stove is simply a double wooden box packed with hay or other insulating medium in which the food to be cooked is placed and closely shut within. It is given a preliminary boiling of a few minutes and then, in tightly covered crocks is placed within the "hay box," so-called, and left for a number of hours, during which time the heat which is conserved by the excellent insulating walls, completes the cooking operation. The hay-box, or fireless cooking stove, enables food to be well cooked with a very small expenditure for fuel, and, of still greater importance, it permits the food to be cooked thoroughly with practically no attention. In the army service it would be possible to have food cooking while in transport, etc.

The use of pure nickel for coinage is advocated by Mr. Albert Ladd Colby in the *Iron Age*. Our present nickel coinage is confined to the five-cent piece which is an alloy of nickel and copper. It is pointed out that pure nickel coins resist wear better than the alloy coins and the imprint lasts longer. Also that heavier and more powerful dies are required, thus making counterfeiting more difficult. Another incidental advantage of the pure nickel coin is that it is attracted by a magnet whereas the alloy coin is not. Notwithstanding the fact that the "nickel" is a very convenient coin, we think that it is a mistake to advocate the extended use of nickel for coinage, even though it may be a superior metal for this purpose. We do not think that anything should be done by the government to increase the intrinsic value of nickel, for it is already too costly from the stand of the would-be user of nickel-steel. From an economic view-point the price of nickel could be very advantageously reduced inasmuch as it would greatly extend the uses of nickel-steel in the constructive arts, and we consider these as of much more importance than that of mere coinage—silver and gold are good enough for that.

In long transmission of power, high voltage means economy in the cost of the transmission line, but under the present conditions affecting electrical generators it is necessary to use step-up transformers in the power station to secure the higher voltages that are used on the longer lines. The transformer, while very efficient, means a certain loss of efficiency, 2½ per cent probably being a conservative figure. The *Electrical World and Engineer* suggests that the construction of generators may be improved so that the need for step-up transformers will be eliminated. It suggests that oil insulated generators be built and in this way generate high voltage directly instead of using the transformer as an intermediate apparatus. While the oil-insulated generator would mean a larger and more expensive machine, it would eliminate the loss due to transformation and considerably simplify the present central station construction.

In a paper upon electric motors read by Mr. H. C. Fashbough before the ninth meeting of the Ohio Society of Mechanical, Electrical, and Steam Engineers, the author refers to the curious fact that central station engineers lay great stress on efficiency when purchasing steam boilers, engines and dynamos. They will limit the variation of efficiency from the highest attainable for the type to a few per cent, but when it comes to the matter of electric meters, they will be purchased almost entirely with reference to price alone, without regard to their efficiency. Now when it is considered that an electric meter is the measuring device by which the revenue is determined, it would seem that this practice is very short-sighted. It is very much on a par with the practice of a merchant who would use scales of very questionable accuracy; one scale might weigh correctly and another indicate from 10 to 20 per cent less than the actual weight of the goods sold, or *vice versa*.

The British Admiralty are to build a war vessel of new type that is a radical departure from previous practice and, should it also prove to be an advance over the older types, will probably have a marked effect upon the warfare of the future. The new ship will be a battleship of the heaviest type and will mount a battery of ten 12-inch guns as against the four 12-inch guns usually carried. There will, however, be no intermediate battery of 6-, 8- or 9-inch guns; but there will be a large number of high velocity 3-inch guns for repelling torpedo boats' attack. Not less remarkable than this battery equipment, however, is the engine power provided, which will be capable of driving the vessel at a speed of 21 knots an hour, or as fast as a high-speed cruiser. To accomplish this, turbines are to be installed of 23,000 horse-power. This is the first instance of the use of turbines on war vessels of large size; although they are being adopted in some cases for naval vessels of small size, largely for the purpose of experiment.

Mr. R. A. Hadfield, in his presidential address before the Iron and Steel Institute, May, 1905, referred to the curious fact that the natives of West Africa are able to produce by a very crude method a high carbon steel which it is difficult to surpass by any modern process. A chisel made of this steel analyzed 1.08 per cent carbon, and all the other elements including silicon, sulphur, phosphorus and manganese, were under 0.10 per cent. While it may be a matter for some wonderment why this primitive steel, which, in common with the steels made by primitive processes in other countries, is so remarkably free from impurities, still, when we reflect, it is not so strange. If the steel did contain certain impurities such as sulphur, for example, it would not be good steel. In short, the primitive steel maker found that certain materials and certain methods of working produced a good metal, the same as the modern steel makers know. If he deviated from a certain line of procedure the steel produced was inferior. Hence, the good product survives while the mistakes are lost. In other words, primitive steel making is probably only another example of the tedious way in which mankind has learned by experience what will and what will not produce a desirable result.

A new high-speed steel called "Unor" is being made by Sheffield Steelmakers, Ltd., Sheffield, Eng., which promises to be an important brand inasmuch as it is much cheaper than most other brands on the market. The price, it is said, will be something like 18 cents a pound delivered in America. It is an air-hardening steel and all that is necessary to harden it is to heat it to a bright red and not beyond the critical point as is the case of many brands of high-speed steel; it is then allowed to cool naturally in the air, without the use of an air blast. It is annealed by heating it a cherry red and letting the heat subside to a very dull red and then plunging into water. Experiments have proved that it can be hardened and softened any number of times without deteriorating the wearing qualities of the steel. Some twist drills made of "Unor" steel were recently tested at the Sheffield Testing Works, drilling a 0.49 carbon steel locomotive tire made by Camel & Co. In this test 49 holes, each 15/32 inch in diameter, and 1⅞ inches deep were drilled at an average speed of 25 seconds each. A 13/16 inch hole drill made from this steel drilled 20 holes 2 inches deep in 16½ minutes, and in both cases the drills were left in good condition.

A paper was presented by Mr. Sydney A. Houghton to the May, 1905, meeting of the Iron and Steel Institute, which gave an interesting example of the failure of an iron plate from fatigue. A traction engine, of the locomotive type used for plowing, exploded with disastrous effects, killing one man. The failure of the barrel was found to be due to the action of the front pedestal bearing with which the barrel of the boiler was supported on the forward axle. The working of the engine over rough ground caused the pedestal to exert a bending effect on the boiler plate which eventually cracked it, thus causing the explosion. Undoubtedly many boiler failures might be traced to a similar cause, especially those of the portable type having the machinery and wheels supported by the boiler which thus takes the place of a frame. While boiler construction is very well adapted to the support of machinery, it may be affected by it in bad designs in such a way that the plates in the immediate vicinity of the supporting pads are subjected to alternating bending stresses which eventually deteriorate to such an extent that they give way. Not every explosion of this character receives the critical examination of that on which Mr. Houghton bestowed his attention.

In the early days of lathe construction when power-driven lathes were unknown, catgut bands were almost always employed for transmitting motion from the foot wheel to the spindle. The great strength and long-wearing qualities of catgut make it a material unapproached by any other for the purpose, yet, seemingly, with the advent of power-driven machinery, its value as belting material has been largely lost sight of. But when it is considered that a catgut cord only 1-10 inch in diameter will work efficiently under a tension of over 300 pounds, for long periods, it is obvious that the material is good for something else besides violin strings. In short, the use of catgut belting for certain machinery should prove much more profitable than leather or other material. Attention is called to the value of catgut for belting by Mr. J. N. Raffard, in the May 31st issue of *Revue de Mechanique*. He says that it will work effectively under a tension of nearly 4,300 pounds per square inch, or ten times the allowable loads for leather belts. A round cord of catgut 0.39 inch diameter should do the work of a leather belt 6 inches wide and 1-5 inch thick. It should be used, however, in endless form as belt or screw fasteners of any kind cause a serious loss of strength. Of course, an objection to the general use of catgut belting is its cost and the small sizes only in which it is available. Another objection, not serious, however, is that it is slightly hygroscopic, *i. e.*, changing with the dampness of the weather.

It is a fact well-recognized, and one previously alluded to in MACHINERY, that much of the progress in the metal-working arts is due to the contest between guns and armor. Processes have been devised and great shops have been built for making armor plate which shall resist the highest power guns, and in

turn, as equally strenuous efforts have been made to devise gunpowder, and projectiles which shall destroy the improved armor plate. The equipment of an armor plate shop or mill is of the most costly character and it is somewhat startling to hear that all this equipment may be rendered of little value by an armor plate process in which the steel is cast instead of being forged. The possibilities of manganese steel in this direction are being exploited and the results indicate that it is possible to make a manganese steel armor plate by the casting process, which equals in every respect the best Krupp cemented plates. A 6-inch unforged, capped manganese shell has perforated a 6-inch Krupp cemented plate when impelled with a powder charge that gave it a striking velocity of 2,000 foot-seconds. The possibility of making armor plate by casting, of a material almost invulnerable to attack, shows how, in the progress of the arts, the complicated gives way to the simple; that improvement is generally an elimination of features which cost time and money and which in the light of progress are found unnecessary. While manganese armor plate will seem like a great achievement, the use of the same material for railway frogs and other purposes will work a far greater change, no doubt.

One of the conditions which must very unfavorably impress the visiting foreigner is the dangerous state of many of the streets of our large cities, especially where extensive improvements are being made. Where excavations are necessary they are usually protected, it is true, by some sort of railings, but they are generally put up in a perfunctory manner, seemingly more for appearance than for actual safety of the public. This state of affairs has been very apparent in the building of the subways in New York City and Brooklyn. Much of this work was done by open cut excavation, the streets being uncovered at the sides, leaving the surface railway tracks suspended, as it were, in mid-air. A miserable railing of rough boards placed two or three feet from the track was generally the only guard provided for preventing accidents and these were usually a greater source of danger than the chasm. So poorly fastened are they along the subway route in Brooklyn that only a slight shock is necessary to loosen the ends of a board which then, as like as not, would swing around and impale some unlucky passenger in a passing car. That such conditions are nothing less than criminal seems to be dimly understood by the great mass of our population. A similar condition in England, for example, would call forth such a storm of protest that no contractor or construction company could ignore it. Here everyone seems to think that a public condition which does not immediately but only remotely concern him, is one that he need not pay any attention to.

Peru possesses a valuable element in the yet undeveloped hydraulic power which exists on both the eastern and western slope of the Cordillera of the Andes. The source of this water supply is the ice cap above the line of perpetual snow which crowns the summit of the range, and the continual and exceedingly heavy snow and rain storms of the high plateaus. All along this vast chain, from Ecuador to Chile, there exists a series of lakes, practically astride the summit of the Andes, at altitudes varying from 12,000 to 17,000 feet above sea level, and these, together with the streams to which they give rise, form the source of enormous hydraulic energy. The volumes of water which descend upon the Pacific side are not necessarily very great, but they are numerous and constant, and their fall is exceedingly rapid. As an example, the river Rimas, which rises in the ice cap of the Cordillera, at an elevation of more than 17,000 feet, debouches on the coast of Callao, with a course not more than 80 miles long. This river is already used as motive power for generating electricity for the railway between Lima and Callao, and could furnish constant and unlimited power over any portion of its course. Similar conditions exist, more or less, with the numerous other rivers and streams all along the 1,500 miles of Pacific littoral belonging to Peru. On the eastern slope of the Cordillera the volume of the streams is greater, for the rainfall is far heavier, due to the well-known climatic conditions to which the Andes give rise. In short, the Andes may be considered as a mighty engine, continually intercepting and storing up the moisture of the continent upon its summits, and thence discharging it again under such conditions as create energy in a limitless form and available for the uses of man.—*Consular Report.*

Mr. H. M. Lane outlined a plan for making a molder in a paper read before the New York meeting of the American Foundrymen's Association, June 6-8. The prime evil that affects most apprentices is that they are affected with the "big wages quick" mania. As a consequence, many boys spend about half their apprenticeship in one shop and then quit and go into another shop where they can get journeymen's wages. Mr. Lane proposed that a trade school for molders be equipped for the manufacture of a broad line of machinery. The plant should be large enough to employ 1,000 hands in all departments and it might manufacture machine tools, lathes, planers, milling machines, drill presses, grinding stands, gas engines, steam engines, sheet metal-working machinery and woodworking machinery. Connected with the establishment there would be a corps of teachers and a regular course would require four years, distributed about as follows: nine months in a series of shop work corresponding closely to that given in manual training schools. During this period he would receive no pay. When the boy enrolls he would be expected to pay down $100, and if at the end of nine months' preparation he decides that the trade is not to his liking, he should be allowed to go and be given back half of the money paid in. If he wants to go on with the trade he would be put first on to molding machines and taught how to make a large number of different classes of molds in this way. From the molding department he would pass to the core department and from the core department to the light work floor, and then to the heavy work floor where he would receive instruction both in green sand and dry sand work, also in loam work. This course would occupy approximately two years and three months. The last year should be elective, the boy being permitted to choose his specialty and spend his last year on it.

A type of street car is used in Cincinnati, Ohio, and some other cities which has a narrow, enclosed vestibule in front for the motorman, and an extended vestibule at the rear for the conductor and the incoming and outgoing passengers. The large rear vestibule is for the convenience of smoking passengers who stand behind a rail which guards the passageway to the interior of the car. This idea has been extended in Montreal in such a way that all passengers pay their fares before entering the car. These cars have the rear vestibule platform 7 feet long, which gives standing room for about 20 passengers. The conductor stands at the inner doorway and collects fare from all who enter. The large vestibule allows a large number to get on without making any delay for the collection of fares, this being done as they enter to the seats. No one is permitted to enter at the front platform, although passengers may make their exits at that platform, the door being opened by the motorman by means of a lever which he operates with his foot. The advantages of the system are that all fares are collected, and that the conductor always stands at the rear of the car, where he has full control of the car and can fully observe the movements of the incoming and outgoing passengers. It also saves the passengers the annoyance experienced on trolley cars of having the conductor squeeze through to collect fares A large proportion of the accidents which occur on street railways are directly traceable to the inability of the conductor to attend to his other duties and collect fares on crowded cars. The Montreal system is one that should appeal to the traveler, conductor and street railway manager alike. One objection to the scheme is that such cars can only run in one direction and loops would have to be provided at the terminals so that the cars can turn completely around before starting on return trips. For service in large cities where street accidents and blocks are frequent, which cause cars to start on their return trips before reaching the terminal, this drawback would be a somewhat serious objection.

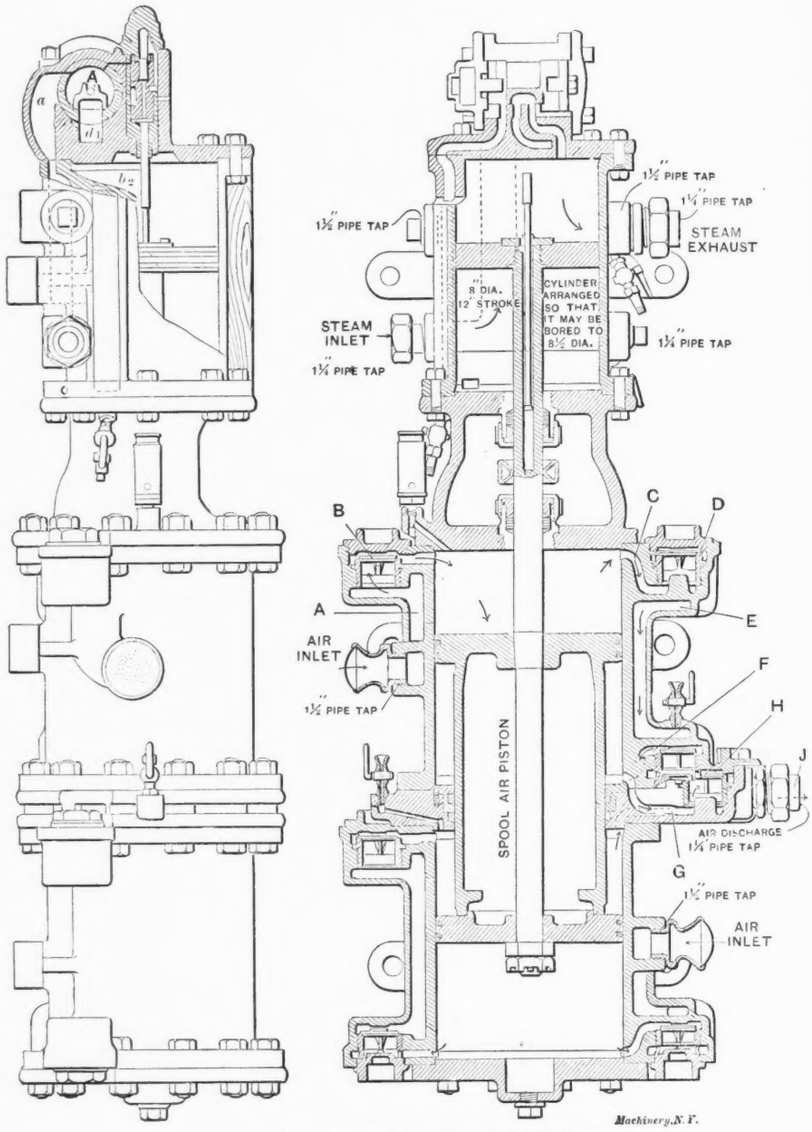
WESTINGHOUSE COMPOUND AIR PUMP.

A new Westinghouse air pump of the compound type was exhibited at the Manhattan Beach convention of the American Railway Master Mechanics' Association, and a description of this pump showing its internal construction and method of operation was given by Mr. F. H. Parke, of the Westinghouse Air Brake Company, in a recent issue of *Railroad Gazette*. The new pump comprises three cylinders placed vertically in tandem; the upper cylinder is the steam cylinder and is 8 inches in diameter, having a stroke of 12 inches. The air cylinder end of the pump consists of two 11-inch cylinders joined by a short centerpiece having an 8¾-inch circular opening fitted with packing rings, as shown in the sectional view, Fig. 2. The air piston is spool-shaped, the ends being 11 inches in diameter and the small diameter of the spool being 8¾ inches, to fit the opening in the centerpiece; the stationary packing rings in the centerpiece fit the spool of the piston, making it airtight. In operation the free air is drawn in at the ends of the air cylinders and is forced by the check valve into the annular spaces around the small diameter of the spool. From this space the air is forced into the main reservoir.

The pump has a normal capacity equal to that of the standard 11-inch pump which has been on the market for some years; but by compounding the air end, only an 8-inch steam cylinder is required. The steam consumption is thereby reduced to about 52 per cent of what the old 11-inch pump required. But this is not the whole of the gain, for, by compounding the air end, the capacity of the pump is increased about 16 per cent when pumped against 90 pounds pressure. This is due to the fact that the low-pressure clearance spaces at the end of compression stroke are filled with air at only 40 pounds pressure, instead of 90 pounds, as in the case in the simple pump. Hence the pressure of the clearance spaces reduces to atmospheric pressure much earlier in the intake stroke than is possible with the simple pump; consequently a larger volume of free air is drawn in at each stroke. From such tests as have been made, it appears that the new pump requires only 45 per cent of the steam per cubic foot of free air compressed that is required by the old 11-inch pump.

The operation of the steam end of the pump is the same as with standard 11-inch pump, but in the air end the operation is, of course, quite different. On, say, the down-stroke, air is drawn in through the strainer at the left through port *A* and inlet valve *B* to the upper pump chamber. The upstroke of the piston compresses this air, forcing it through port *C*, lifting valve *D*, from whence it passes through port *E* and port *F* into the annular space around the spool piston. The second down-stroke of the piston further reduces the volume of air which has already been compressed to 40 pounds, and forces it at a pressure of 90 pounds, through port *G* and valve *H*, into the air discharge pipe leading to the main reservoir.

The action in the lower end of the pump is the same, air being drawn in through the air strainer at the right, but being discharged through the common discharge pipe *J*.



Figs. 1 and 2. Westinghouse Compound Air Pump.

STEEL CAGE BUILDING CONSTRUCTION.

The Tower Building on lower Broadway, which is claimed to be the first example of skeleton construction in which the entire weight of the walls and floors is borne and transmitted to the foundation by a framework of metallic posts and beams, is soon to be dismantled to make way for a larger building. It was erected in 1888-9 and was originated and designed by Architect B. L. Gilbert. Its frontage on Broadway is 21½ feet and the height above the street 160 feet. If the ordinary system of building construction then in vogue had been employed, in which walls of stone or brick carried the entire weight, the available space on Broadway, after taking out the necessary thickness of the walls, would have been only a little more than 10 feet. Hence, in order to erect a profitable building it was positively necessary to invent a new method of supporting the walls other than had heretofore been employed. The result is what the world knows as the "steel cage" construction in which steel beams support the floors and the side walls, the stone or brick portion being merely a skin for filling in the open spaces. One of the strange sights of New York City is the erection of a modern office building, in which the upper floors are being completed first, while the lower floors stand gaunt and empty, the apparently slender steel beams supporting the enormous mass above it. In a recent issue of the *Times Engineering Supplement*, the claim of America being the birthplace of the steel cage construction is disputed, the Crystal Palace erected in London in 1851 being quoted as an early example of that type. The writer says that although the walls of the Crystal Palace happen to have been made of glass, it is easy to see that the architect (Paxton) could have designed any other building on the same system

with the skeleton perfectly capable of carrying a skin of stone or brick. The fact is, however, that he did not design such a building and there is nothing to show that he ever conceived any such idea. It is not what men can do, but what they do do that counts, and the fact that the English architect closely approached steel cage construction does not give Great Britain the right to claim its origin, especially as they never built any structures in which this idea was carried out prior to the Tower Building in New York. The writer bemoans the fact that steel cage construction did not come in vogue in the country in which he claims it originated, but the facts are that the modern office building was entirely impractical until the development of the elevator. It was useless to talk of buildings six or seven stories high before the advent of the modern elevator, for no one, save, perhaps tenement dwellers, could be induced to climb to such weary heights on any matter of ordinary business, but with the coming of the elevator all was changed. The top floors then became the most desirable and the limits of high building construction were only marked by the amount of capital that any builder was willing to put into the construction of its foundations and superstructure. It is presumable that thirty-story buildings will be as common in New York ten years hence as fifteen-story buildings are at the present time. In fact, with the enormous increase of land values, owners are being forced to build high buildings in order to get adequate returns from their investments.

ALCOHOL AS A SOURCE OF POWER.

There is a certain tendency in British engineering circles, says Mr. F. S. Lister in the *Times Engineering Supplement*, to consider that the use of alcohol for a power medium in internal combustion engines is still in its initial experimental stages, and that many very grave difficulties remain to be overcome before it may take equal rank with the heavy and light hydrocarbon oils as a source of power. There have been, no doubt, good reasons for this view, but to those who have given careful attention to the subject it is apparent that any difficulties arising are not really attributable to an inherent defect in alcohol, or to a want of adaptability to the requirements of the reciprocating engine, but are chiefly the result of the restrictions imposed by law upon its use and the prohibitive cost entailed by a high excise duty.

The development of the alcohol motor hitherto has been principally confined to Germany—where it has already an established commercial position—and France. This is no doubt owing to the fact that alcohol is cheaper than either gas or petroleum; on the latter there is a restrictive duty of 21 cents per gallon. Exhaustive tests were carried out in 1903 on alcohol motors of different makes by the German Agricultural Society, which conclusively established its high efficiency. The Marienfeld motor showed an efficiency of 32.7 per cent; others not much less. This is nearly double that of the ordinary petroleum engines, for which 17 per cent may be given as a fair average efficiency.

It will be useful, then, to compare the position of denatured alcohol with that of petroleum as regards its adaptability to internal combustion engines. In the first place, the gasification of alcohol is much more difficult than that of petroleum; it has therefore been found advisable to start the motor with benzine or petroleum and continue this until the temperature of the discharge gases reaches about 158 degrees F. This is a disadvantage that is more apparent than real, and one, no doubt, that will be overcome at a more advanced stage by special devices. Again, the calorific value per unit weight is only about half that of light petroleum oil. Consequently, to obtain an equal explosive charge, double the weight of alcohol is required. This does not, however, indicate that, for a given output of power, double the weight of alcohol is necessary, as when alcohol is used the heat is more efficiently applied. As we have already seen, the efficiency of the alcohol motor is much greater than that of the petrol motor. This is due to several reasons. The range of explosion of admixtures of air and alcohol is very great, actually about twice that of petroleum vapor and air. As a result much more perfect combustion of the fuel takes place, and it is possible to dispense with the exact valve regulation which is necessary when petroleum is used. The heavier alcohol requires less air, so that given equal cylinder capacity more power is obtained from the explosive charge. A factor affecting consumption is the compression within the cylinder. The higher the compression of the charge the lower the fuel consumption; in this respect alcohol gives better results than either benzine or petroleum; as a usual rate of compression about 8 to 1 is practised, while the limit of compression of the oil vapor charge has been reached at about 4 to 1 in the petroleum motor. Again, a further advantage in the development of the alcohol motor will no doubt be derived from the fact that alcohol is readily miscible with water. It has been found that by the introduction of a water spray to the cylinder a more rapid combustion of the charge results, while, owing to the high specific heat of steam, the temperature of explosion is lowered.

On the whole, then, the value of alcohol as a practicable and efficient source of power appears to have been conclusively demonstrated. It gives a high efficiency to the internal combustion engine, valve arrangements may be simplified, there is no deposit formed in the cylinder of products of partial combustion, and there are no mechanical objections to its use. All that appears necessary, then, to insure the general introduction of the alcohol motor is the creation of a wide source of supply of alcohol and the reduction of cost to a basis which will permit of its profitable employment.

GAS AS A MOTIVE POWER AND ITS RELATIVE COST.

Extract from Paper by Mr. W. H. Laurie, presented before the Canadian Society of Mechanical Engineers, March 23, 1905.

In making a comparison of the costs of the various motive powers, the cost of illuminating gas is put at $1.00 per 1,000 cubic feet.

Gasoline.—The consumption of gasoline in a gasoline engine is one-eighth gallon per B. H. P. hour. This at 20 cents per gallon figures out as follows:

$0.125 \times 10 \times 312 = 390$ gallons at 20 cents = $78.00 per B. H. P. per annum.

Illuminating Gas with the Modern Gas Engine.—One B. H. P. can be produced with from 14 to 16 cubic feet of illuminating gas, or, an average of 15 feet per hour. This figures out as follows:

15×10 (hours per day) $= 150 \times 312$ (days per year) = 46,800 cubic feet at $1.00 = $46.80 per annum per B. H. P.

Steam.—Since the average automatic high pressure engine of small powers requires from four to eight pounds of coal per hour per B. H. P., take the average six pounds; this figures out as follows:

6×10 (hours per day) $\times 312 = 18{,}720$ pounds at $4.00 per ton = $37.44 per B. H. P. per annum.

Semi-Water Gas from Anthracite Coal.—The most reputable gas engine builders will guarantee their engines to develop a B. H. P. on one pound of coal in the generator; this figures out as follows:

$1 \times 10 \times 312 = 3{,}120$ pounds of coal, $5.00 per ton = $7.80 per B. H. P. per annum.

Semi-Water Gas, from Gas Coke.—The author has recently obtained a copy of a test of an electric power plant of about 80 H. P. The fuel was common gas coke and the consumption was 0.92 pounds per hour per B. H. P.; this figures out as follows:

$0.92 \times 10 \times 312 = 2{,}870$ pounds of coke at $4.00 = $5.74 per B. H. P. per annum.

Water Gas.—With large gas plants of 500 H. P. and over, the Crossley Bros. can produce a B. H. P. on 0.80 pound of bituminous coal per B. H. P.; this figures out as follows:

$0.80 \times 10 \times 312 = 2{,}870$ pounds of bituminous coat at $4.00 = $5.00 per B. H. P. per annum.

Summary of Cost of Power from Various Motives per B. H. P. Per Annum.

Power from gasoline	$78.00
Power from illuminating gas	46.80
Power from steam engine	37.44
Power from semi-water gas (anthracite coal)	7.80
Power from semi-water gas (common gas coke	5.74
Power from water and producer gas (bituminous coal)	5.00

From the foregoing it will be seen that the gas engine with a suitable gas producer will generate power at a lower rate of cost than any other source of power, although it is only within the last few years that it has been brought to its present high efficiency. Increased sizes and higher compressions are the most marked features in its recent development. These changes have necessitated material modifications of design.

CASEHARDENING.

Abstract of Paper read by Mr. David Flather before the Cycle Engineers' Institute, Birmingham.

The term "casehardening" naturally implies the hardening of the skin of an article, and in order to fully understand the process and its object we must briefly consider the facts and laws upon which it is founded. Carbon has a very great affinity for iron; combines with it at all temperatures above faint red heat. Advantage is taken of this fact in the production of steel by cementation—in fact, the process of casehardening is in reality incomplete cementation followed by water or oil hardening.

For many purposes in cycle work we require articles to have a perfectly hard surface, and yet be of such a nature that there is no chance of their breaking in use. In many instances this result can be obtained with high-class crucible steel, but for axles, cups, cones, and many similar parts, it is extremely difficult to obtain perfect hardness combined with great resistance to torsional, shearing, or bursting strains. For such purposes nothing can meet these requirements so fully as can be done by means of casehardening. The greatest risks in the employment of all steel often occur during its treatment by the consumer, and whether it be the finest cast steel or only common Bessemer, it is of first importance that it should be carefully and properly treated with a view to the work it has to do.

Both iron and mild steel have been employed as material for casehardening; but this is the "steel age," and iron has long passed its day. The steel employed should be prepared, selected, and controlled from the beginning with the object of suiting it to its requirements. There are, of course, many points relating to its composition and treatment by the producer which can only be gained by long experience and by study of the requirements. Suffice it to say that the steel used should be low in carbon and capable of absorbing more carbon with great uniformity when heated under proper conditions; it should contain a minimum of deleterious impurities, and be perfectly sound and free from mechanical faults or weaknesses caused by overheating during the manufacturer's processes.

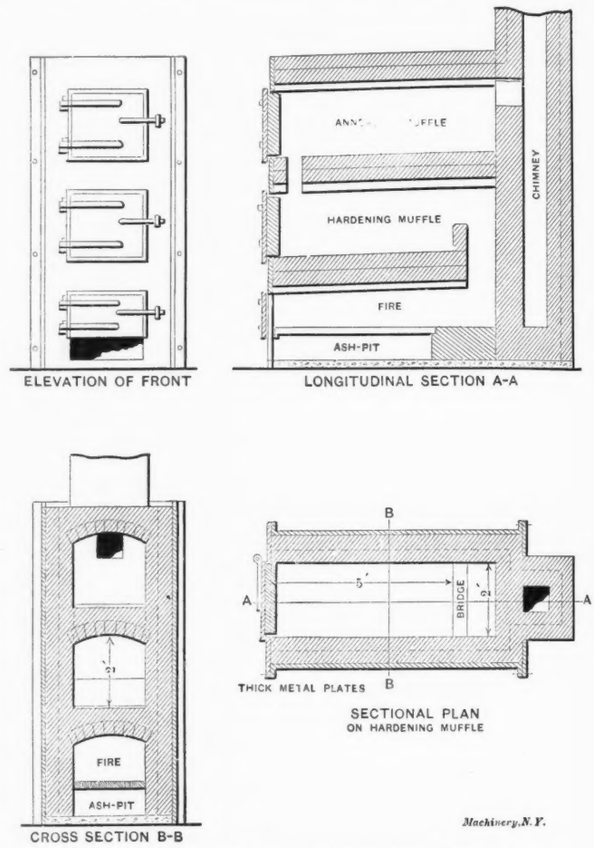
The Casehardening Furnace and Muffles.

The furnace should be so constructed as to be capable of being raised to a full orange heat (1,830 degrees F.), and maintained at that heat with great regularity. It should be so constructed that neither the fuel nor the direct flame can come in contact with the charge. The flames should uniformly impinge on the sides and roof of the muffle in such a manner as to raise them to a high temperature, thus heating the contents of the muffle by radiated and not by direct heat. A furnace designed on this principle not only gives the best result but is also most economical in the matter of fuel. The muffle chamber and flues must, of course, be constructed of firebrick, and the doors should fit closely and also be lined with firebrick. It is important that there should be a small peep-hole in the door, with a cover plate; a hole 1½ inch diameter is quite large enough. This latter is really a most important detail, as it provides against the need of opening the doors in order to judge the heat, and is indeed the most accurate means of estimating the temperature by the eye. The furnace must be fitted with a reliable damper plate or other effectual means of controlling the draft.

The cut shows a small furnace which may be useful as a guide for the erection. The cost of such a furnace is about $175 in Great Britain. The upper chamber in this furnace is not necessary for casehardening, but it may be found useful to have such a chamber and employ it for annealing small articles while casehardening is being done. This will add only very slightly to the amount of fuel used.

Hardening pots are made in both cast and wrought iron, the former being cheaper in first cost, but the latter bear reheating so many times that they are cheaper in the end. The pots should not be of too large dimensions, or there is great risk of articles in the middle of a charge not being carbonized to a sufficient depth. No pot should be above 18 by 12 by 11 inches for such articles as axles, pedal pins, and the like; while for small articles like cups, cones, etc., 12 by 10 by 8 inches is large enough. The pots should each have a plate-lid fitting closely inside.

The carbonizers in general use at the present day are animal charcoal, bones, and one or two other compositions sold under various names, and consisting of mixtures of carbonaceous matter and certain cyanides or nitrates. For very slight hardening, cyanides alone are still found very useful, but no great depth of casing is ever attempted with these. Theoretically, the perfect carbonizer should be a simple and pure



Plan and Elevation of Flather Casehardening Furnace.

form of carbon, and good charred leather gives the most certain and satisfactory results. Care should be taken to avoid poorly charred leather or that made from old boots, belting, etc.

Clay.

As clay must be used for luting round the pot lid, and is also frequently used for stopping off portions to be left soft, it is important to see that a good clay is used, and that it is free from grease. Clay contaminated with grease in any way will cause irregularity in the product.

Reheating Muffles.

As all casehardened articles have to be reheated before quenching, it is important that a suitable furnace should be employed for the purpose. It is not advisable that the reheating should be done in the casehardening muffle, unless it is run specially for the purpose and at a lower heat. If possible a small gas muffle should be used for reheating, and indeed for all hardening work. A properly-constructed gas muffle can be regulated with great exactness, and this is very important in all hardening.

Packing the Muffles.

The carbonizer having been thoroughly dried and reduced to a fine powder, a layer of not less than 1½ inch in depth

is placed in the hardening pot and well pressed down. Upon this are placed the articles to be hardened. Care must be taken to leave sufficient space all round each piece to prevent its touching the others or the walls of the pot; a space of 1½ inch should be sufficient. Another layer of carbonizer is then put in and well pressed down, taking care not to displace any of the articles already packed, continuing until the pot is nearly full, and then finishing off with another layer of 1½ inch at the top. The object in view must be to make the contents of the pot as compact as possible, consistent with a sufficiency of carbonizer in contact with the articles. The more solidly a pot is packed the more effectual is the exclusion of air. The lid is then put on, and the joint all round well luted with clay. By the time the proper number of pots has been filled, the furnace must have been raised steadily to the full working heat.

Furnace Heat.

The proper heat for casehardening is about 1,800 degrees F., or a full orange heat and this should be maintained with great regularity throughout the operation. The length of time occupied in carbonizing is regulated by the depth of casing required, and indirectly by the dimensions of the article. At the close of the carbonizing period the pot is withdrawn from the furnace and placed in a dry place, where it is allowed to become quite cold. It is then opened, the articles taken out and brushed over to remove all adhering matter. If the pot has been properly packed, and luted up, the articles should be quite white, or at least have only a slight film or bloom of a deep blue color; the denser and more inclined to redness is the surface, the more imperfect has been the packing and sealing of the pot.

Reheating and Hardening.

The carbonized articles are now placed in a muffle furnace and steadily raised to a good cherry red (1,470 degrees F.), and then quenched in cold or tepid water or oil, according to the purpose of the articles required. They should remain in the cooling liquid until they are quite cold right through the body of the metal, thus completing the process.

Although the proper temperature for casehardening is about 1,830 degrees F., this temperature may be modified to suit the purpose in view. The absorption of the carbon commences when the steel reaches a low cherry-red heat (1,300 degrees F.); it begins, of course, at the outer surface and gradually spreads until the whole of the steel is carbonized. The length of time this requires depends upon the thickness of the metal being treated. The percentage of carbon absorbed is governed by the temperature, and although the increase of carbon is not in uniform proportion to the rising temperature throughout, it is perhaps sufficient for our present purpose to note that at 1,300 degrees F. iron, if completely saturated, can contain no more than about 0.50 per cent carbon; at 1,650 degrees F., about 1.5 per cent carbon; and 2,000 degrees F., about 2.5 per cent. These results, however, are only obtained when the whole section of the iron has received all the carbon it is capable of absorbing at the given temperature, and is therefore in a state of equilibrium. From this it will be seen that if the process is stopped before the action is complete, the central parts of the iron must contain less carbon than the outside, and upon this fact the process of casehardening is founded.

If we take two pieces of ⅝ inch diameter round mild steel, and heat one of them with a carbonizer at a cherry-red heat, and the other at a bright orange heat, for six hours, the first will be cased to a depth of about 1-32 inch, and the other to a depth of nearly 1-16 inch, while the amount of carbon taken up will be about 0.50 and 0.80 per cent respectively. So that, so far as regards the hardness of the skin, the piece carbonized at the higher temperature gives the best result. From this we learn that a temperature of 1,830 degrees F. will give us sufficient hardness of case.

We have next to find which temperature has the least hurtful effect on the mild steel core, and this can best be found by heating pieces of the mild steel at varying temperatures at and above the selected one for the same length of time, using lime or other inert substance in the pot instead of a carbonizing material, and afterward reheating and quenching in water. Suppose, for example, we take three pieces, heating at 1,830, 2,370 and 2,730 degrees F., or full orange, white and bright white respectively. We shall find that those at 2,370 and 2,730 degrees break very short and have lost nearly all their original tenacity, while that at 1,830 degrees appears tougher and altogether stronger than before.

Having arrived at a knowledge of the right temperature, it remains now to inquire as to the length of time requisite to yield a sufficient depth of case. At a full orange heat a bracket cup of ordinary dimensions should in two hours be hardened 1-32 inch deep, and a bracket axle 11-16 inch diameter in 6 hours would have a case 1-16 inch deep. From this it will be seen that the speed of penetration is not in exact proportion to the time of heating.

Why Hardening Without Reheating is Bad.

We now arrive at that part of the process where a most important improvement has been made—*i. e.*, the final hardening by quenching in water. It formerly was customary at the end of the carbonizing period to open the pot and fling the contents headlong into a tank of cold water. Here and there some of the more careful workers took each article separately, but direct from the pot, and plunged it into water. These latter obtained better results, but even they had a great deal of trouble in the way of breakages and want of regular hardness. Finding that axles taken singly from the pot and quenched were better than those quenched in bulk, and that if allowed to cool down to cherry red they were better still, an application of the old rule to harden on a rising heat led to the now established principle of allowing the pot and its contents to become quite cold, afterward reheating to cherry red and quenching with water. By this means we obtain a case of great hardness with a very tough core—that is, of course, provided a suitable steel is employed.

To understand the reason of this improved method of working we must remember that the exterior of the steel is now of about 0.80 per cent carbon, and that steel of all kinds raised to and maintained at the high temperature employed for casehardening will, unless subjected to mechanical work, show evidence of overheating, being very brittle and liable to easy fracture; and though quenched in water, and consequently hardened, the metal has little or no cohesion and readily wears away. Steel so hardened breaks with a very coarse crystalline fracture, in which the limits of the case are badly defined. It is known that when steel is gradually heated there is a certain point at which a great molecular change takes place, and that perfect hardness can only be obtained by quenching at this critical point. If quenching takes places below the critical temperature, the steel is not sufficiently hard; if above, though full hardness may be obtained, strength and tenacity are lost in part or completely, according as the critical temperature is exceeded by much or by little. This critical point lies between 1,380 and 1,470 degrees F., or cherry-red color heat. It may be asked why it is not sufficient, when taking the article out of the pot, to allow it to cool down to cherry red and then quench it. To this the answer is that the high temperature has already created a coarsely crystalline condition in the steel, and that until it has become quite cold and has again been heated up to the critical temperature, a suitable molecular condition cannot be obtained. When steel is cooled, whether slowly or not, it bears in its structure a condition representative of the highest heat it was last subjected to. From this it will be quite clear that in casehardening, as in all other methods of hardening, the steel must be quenched on a rising heat.

* * *

The Administrative County of London and District Electric Power Company is to construct three electric plants for generating current to supply the whole of London and some of the suburbs. Each plant is to consist of six turbo generators, each of 10,000 kilowatt normal and 20,000 maximum capacity. As these units are larger than any ever constructed the stations will be of unusual interest. Mr. C. F. L. Brown, of Brown, Boveri & Co., is the electrical expert chosen for the work. The Crocker-Wheeler Co., Ampere, N. J., are the American licensees of Brown, Boveri & Co., who act as consulting engineers for them on alternating current work, and they naturally feel a deep interest in the successful outcome.

HEALD CYLINDER GRINDER.

This machine has been developed for the accurate finishing of gas and gasoline engine cylinders, and internal grinding of parts which are of such shape that it is impracticable to rotate them. It is intended to meet the demand for a better method of finishing the interior of engine cylinders than that heretofore employed. In the construction of automobile engines, epecially, the walls are necessarily thin and when the surface is finished by boring or reaming there is a continual tendency on the part of the iron to spring away from the cutting tool. If there are hard and soft spots in the iron, it is almost impossible to have the boring tools cut a perfectly round hole, as the iron in this thin shell will spring away from the tool and come back again after the tool has passed on. With grinding, however, this is not the case, because there is not the pressure against the walls of the cylinder with the grinding wheel that there is with a boring tool, especially when sharp and free cutting wheels are used. The character of the surface also is, for reasons readily understood, far more perfect than can be obtained by boring or reaming.

The machine illustrated by the accompanying cut consists of a main frame or column carrying a grinding spindle which revolves about a horizontal axis. This grinding spindle is mounted in double eccentrics, thus giving a sort of a planetary motion to the spindle and grinding wheel, and making an effective device for getting the correct diameter of the holes and insuring their being perfectly round. Eight different speeds of rotation are given to the eccentrics to handle work of different diameters and conditions. The wheel spindle runs in bronze boxes, provided with a simple adjustment for wear. The end of the wheel spindle is made tapering to receive wheels mounted on collets, thus allowing wheels to be changed without delay in truing up. Provision is also made for feeding out the wheel to regulate the depth of the cut, while the machine is in motion.

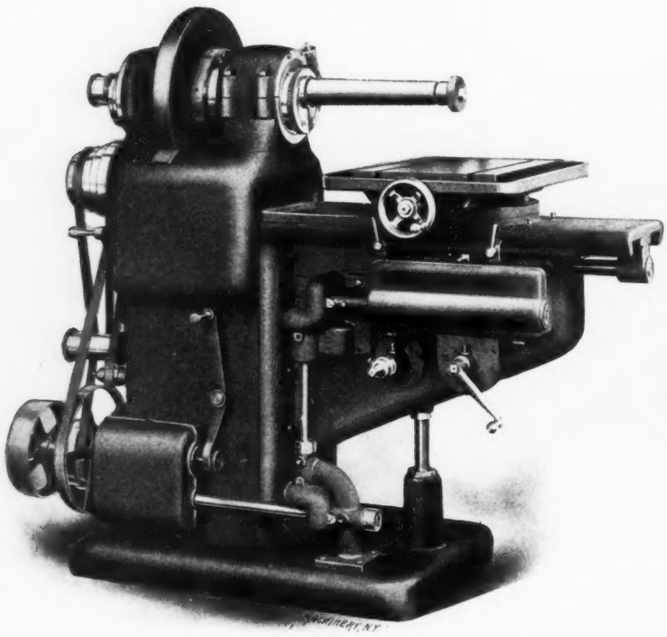
On the front of the column is a knee, carrying the main sliding table, which travels back and forth in a line parallel to the grinding spindle. On the top of this table is a cross slide table for giving crosswise adjustment. In the operation of this machine the work does not rotate but is held in position by means of jigs or other fixtures on the table of the machine, which is a convenient method of handling work when it is large or out of balance so that it is not easy to rotate it. This method of handling also makes it possible to grind duplex cylinders as readily as single cylinders, an advantage that will be greatly appreciated. By means of the vertical adjustment of the knee on the column and the crosswise movement of this upper table any adjustment of the work can be obtained, either to bring a single hole in line with the grinding spindle or to transfer the work from one hole to another, as is necessary when duplex cylinders are to be ground. The travel of the table is automatic, reversing accurately at any point desired. The rate of traverse is controlled by a change-gear box on the column of the machine, giving three different rates of feed to the table.

This machine will finish holes up to 8 inches diameter by 15 inches long. It is built by the Heald Machine Co., Station D-2, Worcester, Mass.

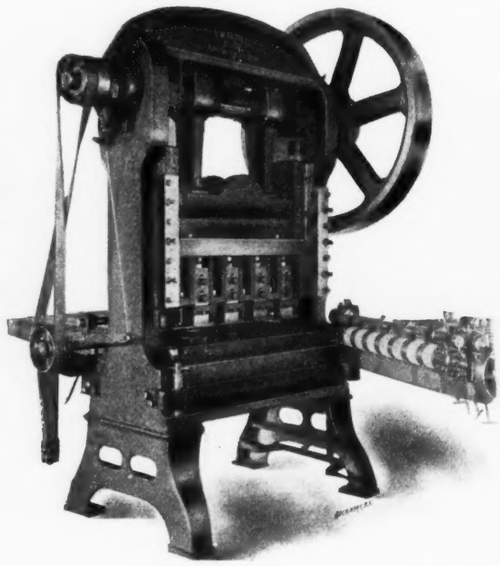
* * *

BLISS PRESS WITH SPECIAL FEED.

In the accompanying half-tones we show a press with an interesting feed, which is specially adapted for handling cardboard, although it may be used for other purposes. This feed consists of two pairs of rolls in front and back of the machine, driven by belts connected with pulleys on the main shaft, and in addition to this there is a belt feed as shown, used for carrying the stock up to and away from the gripping rolls. The tables over which the canvas belts move are so arranged that they may be swung out of the way to give the operator free access to the dies for the purpose of adjusting them. These tables extend about 4 feet both in front and back of the press, and are wide enough to handle sheets of cardboard up to 40 inches. Gages are fitted to the tables so that the narrower sheets may be used when desired. The press is also fitted with adjustable automatic stop fingers to hold the paper in place while being cut. There is no adjustment on the pitmans, but the press is equipped with nine separately adjustable punch holders.



Heald Clyinder Grinder.



Bliss Press with Special Feed

Some of the principal dimensions of this machine are as follows: Width between uprights, 44 inches; distance between gibs, 38 inches; weight of balance wheel, 1,300 pounds; total weight of machine, 13,000 pounds. The press is built by E. W. Bliss Co., No. 5 Adams Street, Brooklyn, N. Y.

* * *

The Republic Engineering Company, Pittsburg, Pa., is making a new shaft coupling which has some decidedly novel points. The gripping element is in the form of a coiled spring. This is enclosed in a cast-iron cylindrical casing and is wrapped tightly around the ends of the two shafts by means of nuts threaded on its ends. It has no projecting parts to make it dangerous; it will couple shafts which vary slightly in diameter and will increase its grip as the load which it transmits is increased.

THERMIT WELDING LOCOMOTIVE FRAMES.

Not the least interesting feature of the recent Manhattan Beach Convention of the American Railway Master Mechanics' Association was the daily demonstration of the Goldschmidt Thermit Company, in welding heavy pieces of wrought iron, representing a broken locomotive frame, by the thermit process. The pieces were 3 x 4 inches and were fixed in a mold of the character shown in Fig. 1. When all was ready, the reaction in the crucible and the pouring of the metal making the weld, occupied the time of perhaps one minute. The demonstrations, which took place in a sand lot near the Oriental Hotel, were a conclusive proof to those who assembled of the remarkable power of thermit for welding locomotive frames and similar parts. The fact that frames may be welded *in situ* makes the process one of great value in locomotive repair work, inasmuch as the labor necessary to remove a broken frame and carry it to the blacksmith shop is generally more than the actual work of repair.

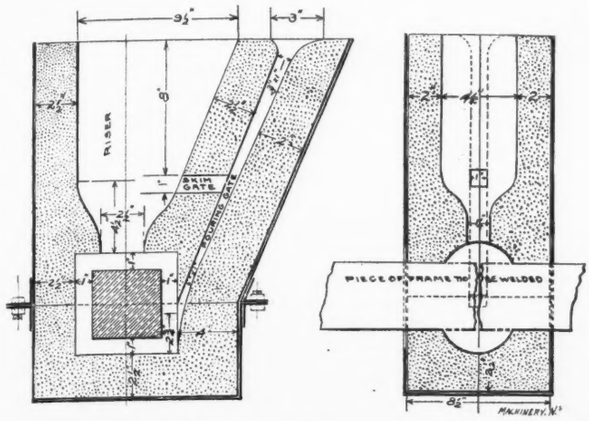


Fig. 1. Section through Mold which is Built around the Part to be Repaired.

The accompanying half-tone, Fig. 2, shows the set-up of a thermit crucible for welding a broken locomotive frame in the Collinwood shops of the Lake Shore & Michigan Southern Railway; and Fig. 3 shows the welded frame with the slag riser remaining on top. It will be noted that the metal forming the weld, makes a collar around the frame about ½ or ¾ inch high. Where this projection does not interfere, it is left in place in order to make a thoroughly strong job. Fig. 4 shows the welding of the broken spokes of a locomotive driving wheel in the Elkhart shops of the same road. The ordinary method of igniting the thermit is by means of a special igniting powder supplied for the purpose, but in the Elkhart shops an electric spark is employed instead.

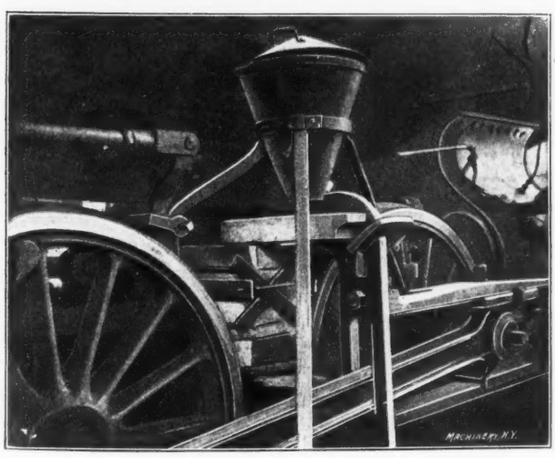


Fig. 2. Crucible in place over Mold, ready for Ignition and Pouring.

In welding a locomotive frame, or any other broken part, the fracture must be opened sufficiently to allow the molten thermit to enter in the break. This may be done by pulling or springing the frame apart so as to leave, say, ⅜ or ½ inch clear space throughout the crack; or a line of holes may be drilled in the crack to accomplish the same purpose. When the frame is sprung apart, the pressure is released 25 or 30 seconds after the thermit has flowed, so that the parts may

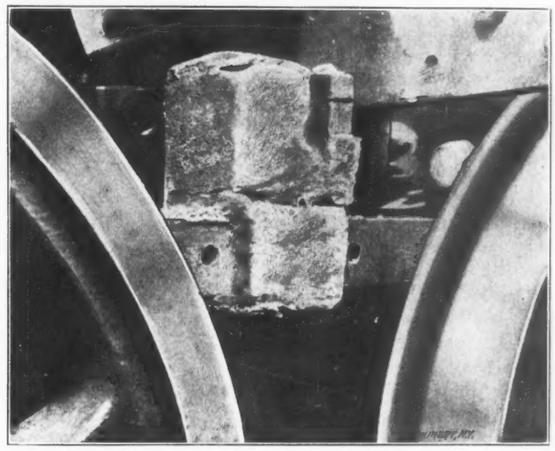


Fig. 3. Repaired Fracture, after Removal of Flask, showing Slag Riser.

assume their proper relation before the metal sets. It is customary to tram the frame across the break and to allow about 3/16 inch for shrinkage.

About 60 to 75 pounds of thermit will weld a 4 x 5-inch section; but this quantity may be reduced about 20 per cent by adding iron punchings at the rate of one pound of punchings in place of two pounds of thermit. Thus, instead of using 75 pounds of thermit, 60 pounds may be used and 7½ pounds of punchings. In making any weld, however, the space to be

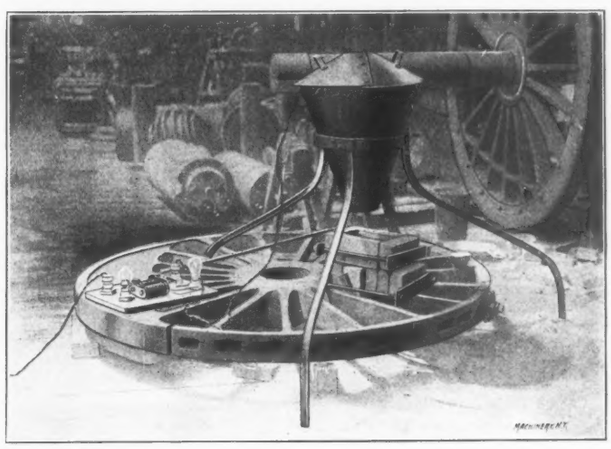


Fig. 4. Crucible, Mold, and Ignition Apparatus, ready for the Repair of a Broken Driving Wheel Spoke.

filled with the molten metal can be carefully measured and its volume computed. Since 9½ ounces of thermit make about 1 cubic inch of steel, it follows that there will be required as many ounces of thermit as there are cubic inches in the weld, times 9½.

* * *

When the mica insulation between commutator bars becomes burned down by sparking until it is below the level of the bars, short circuits between adjacent bars become a serious trouble. It is claimed that the commutator in which the mica insulation has been burned away so as to permit the accumulation of carbon dust, can be permanently repaired by digging out all the dirt and burnt mica and filling in the cavities with thin paste of litharge and glycerin. After filling, the paste is baked with a soldering iron or blow-pipe into a hard compound which may be filed off smooth and even with the commutator's surface. The litharge and glycerin should be thoroughly ground together when used as a cement, as the intimate mixture of the parts is very necessary to secure the best results. Litharge and glycerin cement is also used for setting glass plates in metal frames.

PROPORTIONS OF TWIST DRILLS.

H. D.

The following is a set of empirical formulas and tables for the proportions of twist drills. The lack of uniformity of the main dimensions of such drills, even when manufactured for the market, has been noted in many instances, and the following is an attempt to systematize the proportions of same, giving proper dimensions at the same time as insuring uniformity.

The dimensions referred to above, and for which formulas are provided are, the total length, and the length of the grooved portion. In order to establish uniformity in regard to the total lengths, taper shank and straight shank drills ought to have the same total lengths. As the length of the taper shank always must be some "standard" (usually and preferably Morse standard taper) formulas are not given for the lengths of grooved parts on taper shank drills, as these lengths will, when the total length is given, depend entirely upon the length of the Standard taper used. It is obvious that after the length of the taper shank is deducted from the total length, the remaining portion will be grooved as far up towards the taper shank as practicable. For straight shank drills, however, a formula is given which provides for well proportioned lengths of shank and grooved portion.

As the angle of helix of a twist drill is one of the most important factors influencing its cutting qualities, the lead must be chosen so as to give a proper angle between the direction of the groove and the center line of the drill. This angle will be 24° 10′ if the lead given by the formula is used. It is obvious that every lead given in the table cannot be obtained on every universal milling machine, but in cases where this trouble is met with it is preferable to use the nearest larger lead for drills made of some kind of high speed steel, and the nearest lower lead for drills that are made out of common tool steel.

TABLE I. MAIN DIMENSIONS OF TWIST DRILLS.

Diameter.	Total Length.	Length of Groove on Straight Shank Drills.	No. of Morse Taper on Morse Taper Shank Drills.	Lead of Grooves.
3	21	15	5	21
2 15/16	20 3/4	14 13/16	5	20 9/16
2 7/8	20 1/2	14 5/8	5	20 1/8
2 13/16	20 1/4	14 7/16	5	19 11/16
2 3/4	20	14 1/4	5	19 1/4
2 11/16	19 3/4	14 1/16	5	18 13/16
2 5/8	19 1/2	13 7/8	5	18 3/8
2 9/16	19 1/4	13 11/16	5	17 15/16
2 1/2	19	13 1/2	5	17 1/2
2 7/16	18 3/4	13 5/16	5	17 1/16
2 3/8	18 1/2	13 1/8	5	16 5/8
2 5/16	18 1/4	12 15/16	5	16 3/16
2 1/4	18	12 3/4	5	15 3/4
2 3/16	17 3/4	12 9/16	5	15 5/16
2 1/8	17 1/2	12 3/8	5	14 7/8
2 1/16	17 1/4	12 3/16	5	14 7/16
2	17	12	4	14
1 15/16	16 5/8	11 3/4	4	13 9/16
1 7/8	16 1/4	11 7/16	4	13 1/8
1 13/16	15 7/8	11 3/16	4	12 11/16
1 3/4	15 1/2	10 15/16	4	12 1/4
1 11/16	15 1/8	10 5/8	4	11 13/16
1 5/8	14 3/4	10 3/8	4	11 3/8
1 9/16	14 3/8	10 1/16	4	10 15/16
1 1/2	14	9 13/16	4	10 1/2
1 7/16	13 5/8	9 9/16	4	10 1/16
1 3/8	13 1/4	9 5/16	4	9 5/8
1 5/16	12 7/8	8 15/16	4	9 3/16
1 1/4	12 1/2	8 5/8	3	8 3/4
1 3/16	12 1/8	8 3/8	3	8 5/16
1 1/8	11 3/4	8 1/16	3	7 7/8
1 1/16	11 3/8	7 13/16	3	7 7/16
1	11	7 9/16	3	7
15/16	10 5/8	7 5/16	3	6 9/16
7/8	10 1/4	6 15/16	2	6 1/8
13/16	9 7/8	6 5/8	2	5 11/16
3/4	9 1/2	6 3/8	2	5 1/4
11/16	9 1/8	6 1/16	2	4 13/16
5/8	8 3/4	5 13/16	2	4 3/8
9/16	8 3/8	5 1/2	1	3 15/16
1/2	8	5 1/4	1	3 1/2
7/16	7 5/8	4 15/16	1	3 1/16
3/8	7 1/4	4 11/16	1	2 5/8
5/16	6 7/8	4 3/8	1	2 3/16
1/4	6 1/2	4 1/8	1	1 3/4

TABLE II. MAIN DIMENSIONS, WIRE GAGE SIZES, TWIST DRILLS.

No. of Steel Wire Gage.	Diameter in inches.	Total Length.	Length of Groove.	Lead of Grooves.
1	.2280	4	2 3/4	1 5/8
2	.2210	3 15/16	2 11/16	1 9/16
3	.2130	3 7/8	2 5/8	1 1/2
4	.2090	3 13/16	2 9/16	1 7/16
5	.2055	3 3/4	2 1/2	1 7/16
6	.2040	3 3/4	2 1/2	1 7/16
7	.2010	3 3/4	2 1/2	1 7/16
8	.1990	3 11/16	2 7/16	1 3/8
9	.1960	3 11/16	2 7/16	1 3/8
10	.1935	3 5/8	2 3/8	1 3/8
11	.1910	3 5/8	2 3/8	1 5/16
12	.1890	3 9/16	2 5/16	1 5/16
13	.1850	3 9/16	2 5/16	1 5/16
14	.1820	3 1/2	2 1/4	1 1/4
15	.1800	3 1/2	2 1/4	1 1/4
16	.1770	3 7/16	2 3/16	1 1/4
17	.1730	3 3/8	2 1/8	1 3/16
18	.1695	3 3/8	2 1/8	1 3/16
19	.1660	3 5/16	2 1/16	1 3/16
20	.1610	3 1/4	2	1 1/8
21	.1590	3 1/4	2	1 1/8
22	.1570	3 1/4	2	1 1/8
23	.1540	3 3/16	1 15/16	1 1/16
24	.1520	3 3/16	1 15/16	1 1/16
25	.1495	3 1/8	1 7/8	1 1/16
26	.1470	3 1/8	1 7/8	1
27	.1440	3 1/16	1 13/16	1
28	.1405	3 1/16	1 13/16	1
29	.1360	3	1 3/4	15/16
30	.1285	2 15/16	1 11/16	7/8
31	.1200	2 13/16	1 9/16	13/16
32	.1160	2 3/4	1 1/2	13/16
33	.1130	2 3/4	1 1/2	13/16
34	.1110	2 3/4	1 1/2	3/4
35	.1100	2 11/16	1 7/16	3/4
36	.1065	2 11/16	1 7/16	3/4
37	.1040	2 5/8	1 3/8	3/4
38	.1015	2 5/8	1 3/8	11/16
39	.0995	2 9/16	1 5/16	11/16
40	.0980	2 9/16	1 5/16	11/16
41	.0960	2 5/8	1 3/8	11/16
42	.0935	2 5/16	1 3/16	5/8
43	.0890	2 1/4	1 1/8	5/8
44	.0860	2 1/4	1 1/8	5/8
45	.0820	2 3/16	1 1/16	9/16
46	.0810	2 3/16	1 1/16	9/16
47	.0785	2 1/8	1 1/16	9/16
48	.0760	2 1/8	1	9/16
49	.0730	2 1/16	1	1/2
50	.0700	2	15/16	1/2
51	.0670	2	15/16	1/2
52	.0635	1 15/16	7/8	7/16
53	.0595	1 7/8	7/8	7/16
54	.0550	1 7/8	13/16	3/8
55	.0520	1 13/16	3/4	3/8
56	.0465	1 3/4	11/16	5/16
57	.0430	1 11/16	11/16	5/16
58	.0420	1 11/16	11/16	5/16
59	.0410	1 11/16	11/16	5/16
60	.0400	1 11/16	5/8	5/16

As Morse standard taper shanks are the most commonly used on drills, a column is given in the table showing for what size drills different sizes of Morse tapers should be used. Taper shanks are not used on any drills smaller than ¼-inch diameter.

Dimensions given in Tables I. and II. are figured from the formulas, and when the result has been an uneven fraction of an inch, the result has been given in the nearest sixteenth.

L = total length.

G = length of grooved part.

D = diameter of drill.

S = lead.

For the lead of grooves the formula

$$S = 7 \times D$$

should be applied on all sizes.

For the total length:

1. From 3 inches diameter to 2 1-16 inches diameter

$$L = 4 \times D + 9 \text{ inches.}$$

2. From 2 inches diameter to ¼ inch diameter

$$L = 6 \times D + 5 \text{ inches.}$$

3. From No. 1 to No. 40 steel wire gage
$$L = 11 \times D + 1\frac{1}{2} \text{ inches.}$$
4. From No. 41 to No. 60 steel wire gage
$$L = 12 \times D + 1\ 3\text{-}16 \text{ inches.}$$

For the length of grooved parts:

1. From 3 inches diameter to 2 1-16 inches diameter
$$G = 3 \times D + 6 \text{ inches.}$$
2. From 2 inches diameter to ¼-inch diameter
$$G = 4\frac{1}{2} \times D + 3 \text{ inches.}$$
3. From No. 1 to No. 40 steel wire gage
$$G = 11 \times D + \frac{1}{4} \text{ inch.}$$
4. From No. 41 to No. 60 steel wire gage
$$G = 10 \times D + \frac{1}{4} \text{ inch.}$$

In connection with the data above it might be proper to add a few general remarks in regard to twist drills.

The keenness and durability of the cutting edge depend upon three main factors, viz.: 1. The clearance given to the cutting edge by grinding. 2. The angle of one cutting edge to the other, and 3. The degree of twist of the groove, *i. e.*, the lead.

It is obvious that the speed of the various points of the cutting edge is different according to the distance from the center; hence, the cutting point at the corner operates at the highest rate of cutting speed, and thus performs the heaviest duty. Therefore the angle of clearance should be so selected that this corner is given the most desirable angle for durability. The keenness of the corner also depends upon the angle of the cutting edges with the center line; most manufacturers make this angle 60 degrees, some—amongst them Morse Twist Drill & Machine Co.—59 degrees. However, different angles will be found more suitable for different metals; thus, a drill for brass will cut more satisfactory with an angle of 45 degrees between the cutting edges and the center line.

It will be noted that only one lead is given for the groove in the formulas above (7 × diameter). This lead will be found satisfactory for all ordinary conditions. However, it is desirable on twist drills running at a very high speed to increase the lead somewhat. If for some reason or other a drill has to be used at a slower speed than ordinary, better results will be obtained by a slight decrease in the lead.

It is a well-known fact that at present all twist drills are made with two flutes, but twist drills having three or more flutes have been devised, made, and tried. The advantage gained by adding to the number of cutting edges has, however, not been great enough to justify the increased cost of manufacture. When added to this comes the weakness caused by the increased number of grooves, and the complicated operation of correctly grinding such drills, it is clear why drills having two flutes only have been and should be adopted.

* * *

LINK MILLING ATTACHMENT.

The Warner Instrument Co., Beloit, Wis., manufacture an instrument, called an auto-meter, for indicating in direct reading the speed in miles per hour at which a motor car is traveling at any moment. The device works on the same general principle as the cut-meter made by the same concern for indicating the working speed of lathes, planers and other machine tools, but motion is conveyed to it differently, the instrument being driven from the front wheel by a flexible shaft of simple and interesting construction. The sketch, Fig. 1, shows the scheme of flexible shaft construction. The links *A* are pieces

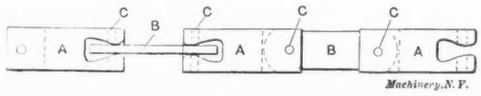


Fig. 1. Simple Flexible Shaft, used for Connecting "Auto-meter" with Wheel of Automobile.

of round steel rod cut to length and having a dovetail slot milled in each end, but in planes at right angles to each other. The links *B* are merely flat steel pieces which loosely fit in between the jaws of the round links formed by the dovetail slots; the round and flat links are held together with rivets, *C*, which loosely fit in *B*.

The milling of the dovetail slots in the round links is accomplished with a simple attachment for a hand milling machine designed by Mr. Cadman, the shop superintendent. Perhaps the most interesting feature of the device, which is shown in Fig. 3, is that it works without causing many saw breakages, inasmuch as the saw is required to cut a slot wider than the saw's thickness at the bottom but of the same width at the top. It is one example of many surprising things that have become feasible with the advent of high-speed steel. The link in which the dovetail slot is to be cut, is held in an oscil-

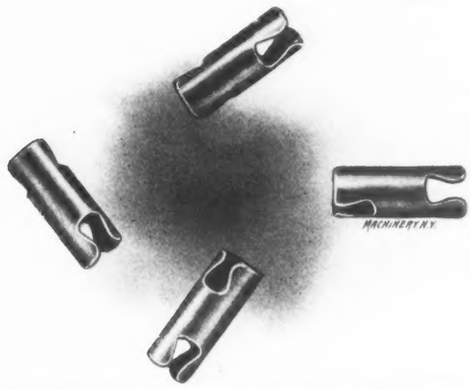


Fig. 2. Links of Flexible Shaft, showing Cut made by Milling Attachment.

lating vise, and is fed against a cutter or slitting saw made of high-speed steel, running at a peripheral speed of about 250 feet per minute. As the link passes under the saw its oscillatory movement causes the bottom of the slot to be cut to a greater width than the top, the axis of oscillation being through the end of the link and at right angles to it, and parallel with the plane of the saw. With the saw running at

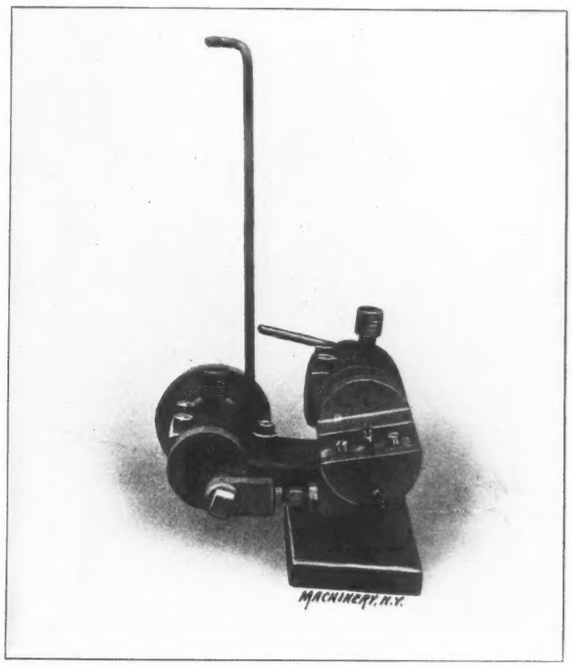


Fig. 3. Attachment for Milling Dovetail Slots in Links shown in Fig. 2.

a peripheral speed of 250 feet per minute and the links oscillated at the rate of 450 times per minute, the operator is able to mill about 1,000 slots or 500 links per day.

* * *

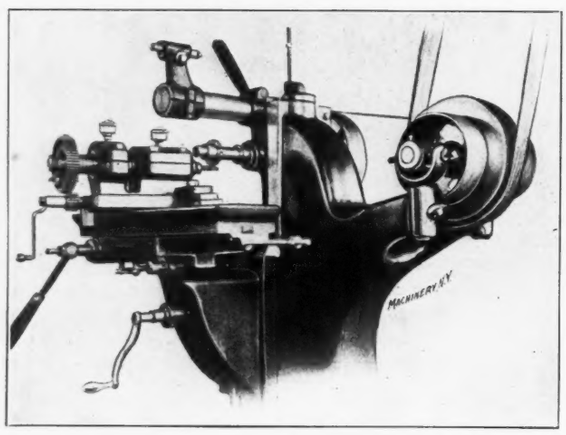
In an address delivered by Captain O. C. Horney, of the Watervliet Arsenal, before the Young Men's Christian Association, on the subject of gunpowder and projectiles, note was made of the enormous pressure developed in modern guns. The pressure developed by a full powder charge on the nose of a breech-block of a 12-inch gun is something like 4,000,000 pounds; on that of a 16-inch gun the pressure is 11,000,000 to 12,000,000 pounds. To make these figures more impressive, especially the latter, it might be added that when the 16-inch gun (of which the United States possesses only one), is fired, the breech-block sustains a pressure greater than the ultimate tensile strength of mild steel bar 14 inches square.

ITEMS OF MECHANICAL INTEREST.

MILLING SQUARE THREAD SCREWS.

The cut shows an attachment for a Whitney hand milling machine which is used in the shop of the George Gorton Machine Company, Racine, Wis., for milling square thread screws, used in the adjustment of an engraving machine spindle. The screw has the approximate dimensions of 1 1-32 inch length, ½-inch diameter over top of thread, 7-16-inch diameter at bottom of thread, lead 5-16 inch, width of land 3-32 inch, width of groove 7-32 inch, diameter hole ¼ inch.

The attachment is a simple device consisting of a casting with two bearings, one of which is bored for a nut and the other to the outside diameter of the lead screw. A gear is

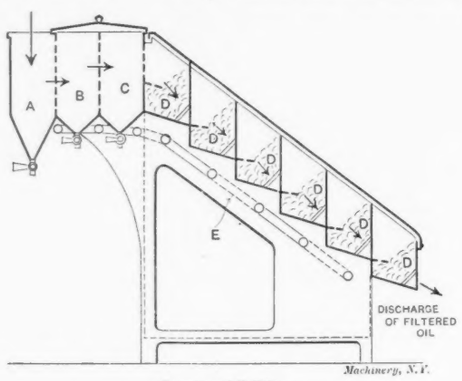


Attachment for Milling Square Threads on Whitney Hand Miller.

mounted on the outer end of the lead screw, and with it is meshed a pinion which is operated by hand. The opposite end of the lead screw terminates in a small spindle on which is mounted the blank to be milled. The attachment is swiveled on the milling machine table to the proper angle and the operator feeds the device slowly against the cutter until the gear brings up against a stop. The thread, of course, is not exactly square, but is a close approximation of it, being so nearly square that a sample would readily pass as a square thread screw were it not known that the thread was milled. The fact that the thread is milled precludes the possibility of its being square, as a square thread screw, of course, cannot be milled with the ordinary type of axial milling cutter.

GERMAN OIL FILTER.

An oil filter of rather novel construction is described by Ernest L. Harris, U. S. Commercial Agent at Eibenstock, Germany, in a recent consular report, of which a sectional view is shown in the accompanying cut, to illustrate the method of working. The dirty oil is first poured into receptacle *A*, where



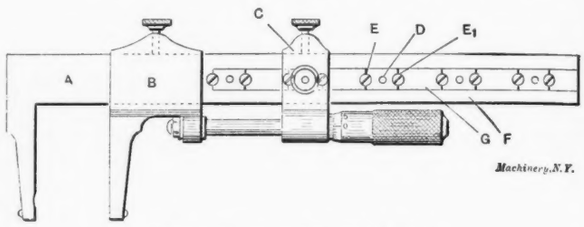
German Oil Filter.

the heavy impurities sink to the bottom from whence they may be drawn off through the faucet at the bottom. The same process takes place progressively in chambers *B* and *C*, by which time the greater portion of the heavy impurities has been deposited so that all that remains to be removed of the filtering material is that having practically the same specific gravity as the oil. These impurities are removed in passing through a series of filtering troughs *D* situated on an inclined plane. The filtering troughs have a removable cover, which construction allows the filtering material to be conveniently examined and changed, and permits any particular filtering chamber to be changed independently of the others.

Although it is not so specifically stated in the consular report, it appears from the cut that a pipe coil *E* is provided underneath the settling and filtering chambers for warming the oil. This is a very necessary feature of any oil filter, as in cold weather the dirty oil becomes very thick and heavy, and it filters very slowly or not at all until warmed up to 100 degrees or more.

IMPROVED MICROMETER BEAM CALIPER.

In a beam caliper having a sliding micrometer jaw with or without a separate clamping slide, it is necessary to have the beam divided into unit spaces, at which the jaw or slide may be accurately fixed, the micrometer screw then being used to cover the distance between the divisions. But it is difficult to construct a beam caliper of this type with holes for a taper setting pin, at exactly equal distances apart; consequently a plan that is generally followed in making such tools is to provide as many holes through the slide and beam as there are inch divisions, each hole being drilled and reamed through both the slide and beam at once. If it were attempted to drill the holes through the beam at exactly one inch apart, having only one hole in the clamping head and using it as a jig for the purpose, it would be found very difficult, if not impossible, to get the holes all of one size and exactly one



Improved Micrometer Beam Caliper.

inch apart. The design of the micrometer beam caliper shown in the accompanying cut, which was patented by Mr. Frank Spalding, Providence, Rhode Island, is such, however, that it is not necessary to drill more than one hole through the clamping slide. The beam, *F*, is grooved longitudinally and in the groove are fitted hardened steel adjusting blocks in which a taper hole, *D*, is accurately finished. Between the blocks, *E*, are filling pieces, *G*, which are brazed or otherwise fastened in the groove. Holes are drilled, tapped and countersunk between the blocks and the filling pieces *G*, in which are fitted taper head screws, $E\,E_1$. The construction is thus obviously such that the blocks may be shifted longitudinally by loosening one screw and tightening the other. In constructing the caliper the holes through the beam are drilled as accurately as possible, one inch apart, and centered in the longitudinal groove, but are made larger than the holes in the blocks so as to provide for slight adjustment.

* * *

The Cement Age tells of a novel use of cement, it being no less than repairing a hole in the hull of a British steamer. Recently at Newport News, the steamer *Alburea* went into dry dock for repairs, and it was discovered that a large hole through her bow, received through contact with a sharp pointed rock in the Straits of Magellan, had been temporarily filled with a mass of timber, canvas, ballast rock and Portland cement, and that this temporary filling enabled the vessel, without further damage, to make her port. The cement was so strong that the chief of the hull construction at the dry dock found that it would take some six weeks to chip it out with the ordinary appliances, and finally he was compelled to put in small charges of dynamite, and after three days of blasting the cement was at last removed, without injury to the vessel upon the dry dock.

LETTERS UPON PRACTICAL SUBJECTS.

MODERN WORK WITH ANCIENT TOOLS.

Editor MACHINERY:

The four accompanying photographs, which, I trust, will be of interest to the readers of MACHINERY, show a high-pressure steamboat engine cylinder built at a shop in which the writer worked some time ago. The engines being built were compound, and cylinder sizes are as follows: Two low-pressure cylinders, 63 inches bore by 144 inches stroke; length over all, 13 feet 6 inches; weight, 48,000 pounds. The above cylinders were not cast or machined in the shop that had the contract as they could not handle them, though they were assembled there, being handled by jackscrews, etc., and carried down the streets of the city, on planks and rollers a distance of ten blocks, by a house-moving apparatus and horse power. The high-pressure cylinders were 28 inches by 144 inches by 136 inches over all; weight, 24,000 pounds; and designed for 200 pounds pressure.

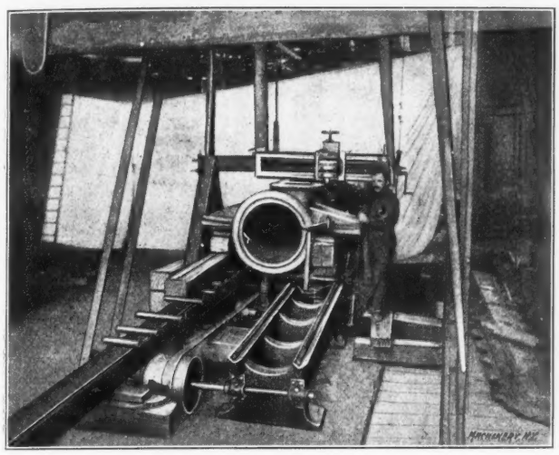


Fig. 1. A Small Planer Widened to take in a Large Cylinder.

Fig. 1 shows an end view of the cylinder, which measures 64 inches across to ends of supporting lugs shown. The object sought was to plane the seats for the steam chests (shown at top of photo between lugs) a surface of about 26 inches by 14 inches. The planer was an old New Haven, which had been in use forty-two years, and could be heard two blocks when running. It was 40x40 inches and was widened out about 30 inches for the job at hand. The housing was taken out on the outboard side and moved over on the stone foundation, holes

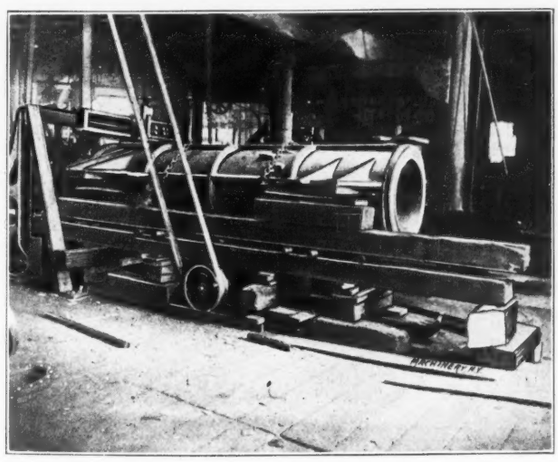


Fig. 2. Method of Supporting Overhang of Cylinder.

drilled in the rock and bolted there. The crossrail was lengthened with a 10-inch I beam and shored up with 8x8-inch timbers as shown in Figs. 1 and 3. An extra countershaft was put on the floor in front of the planer bed, and a belt was run in a horizontal position under the blocking shown. Timbers, 12x12 inches, were blocked up on the off side of the planer, for a runway to support the overhung part of cylinder. Some pipe was trued up to a uniform size for rollers,

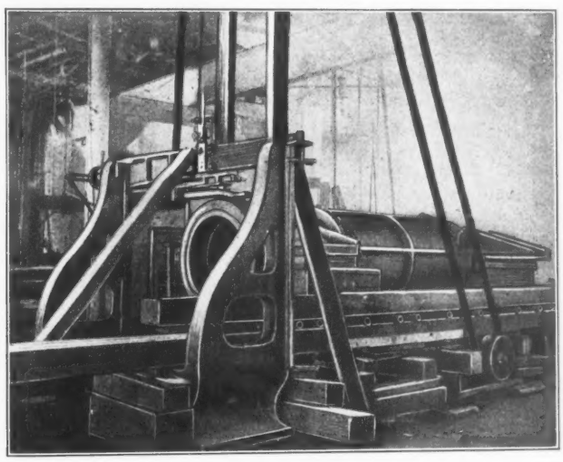


Fig. 3. Bracing for Extended Crossrail

and another 12x12-inch timber was bolted to the cylinder as a shoe to roll along with the travel of the planer bed. The original driving pulley is shown in Fig. 1, just beside the gear and pinion and under the forward end of cylinder. The countershaft was in part bolted to the end of the planer bed.

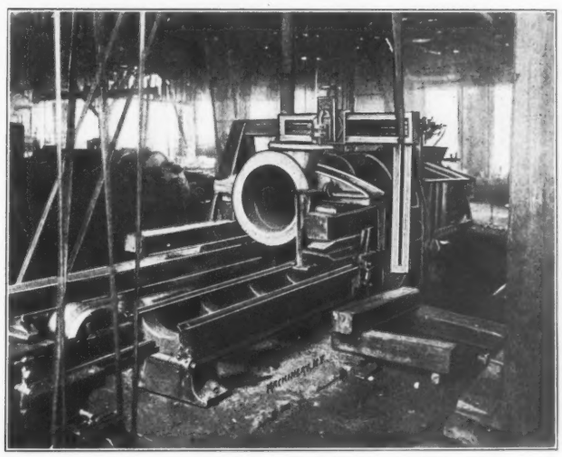


Fig. 4. Blocking, Clamps, etc., for Holding Work on Platen.

As there was no crane available to handle a piece this size, it was put on and off the planer by jackscrews, crowbars and a good supply of cuss-words. The shaft for these engines weighed 40 tons and was of nickel steel, 47 feet long, and hollow. This shop has since gone out of business—died after this job.

ERNEST J. BUCHET.

Dubuque, Ia.

BLANKING AND FORMING DIES.

Editor MACHINERY:

I send two sketches of a class of dies that has helped me out of more than one tight place. In these dies of the "follow" or "gang" type the blank is partly outlined, pierced and formed before it is finally dropped through the blanking die proper.

The first three figures show the punch, and two views of the die which produces the blank, Fig. 4. The punch needs no description, as the sketch is sufficiently clear. In Fig. 2 we have a sectional view of the die on a line through the center of hole *b* and ears *d d*. In cavities *a* and *b* there are spring plungers. These plungers form a solid bottom for forming portions of blank marked *a* and *b*. The die *B*, of tool steel, is

made as usual, and then the cavities *a* and *b* are recessed from the back and the plungers fitted so that normally their tops are flush with the top of die. Enough play is left in the recess underneath them so that they will bottom solidly on the cast-iron bolster *A* when portions *a* and *b* of the blank are properly formed. The length of the punches is regulated, of course, to meet these conditions. Springs in bolster *A* force these plungers up flush with the face of the die as soon as the pressure of the punch is released; they should be made heavy enough to act as strippers.

On introducing a strip of stock at the right side of die almost to cavity *b* and tripping the press, we pierce the two rivet holes shown in blank; also blank and form portion *a*, Fig. 4. The punch, of course, is relieved at the bend the full thickness of the stock. Moving to next position, cavity *c* forms a stop by ear *a* dropping into it. Then, on tripping the press, portion *b* is depressed and the punch, being relieved at *d d* and *e* as before, cuts through the metal around *b* with the exception of the relieved portions merely bending those parts. The next operation cuts out *d d* and *e* and drops the blank through the dies pierced, formed and blanked out.

The punch and die shown in Figs. 5 and 6 is for making the pawl shown in Fig. 7. This die also pierces, forms and blanks the piece.

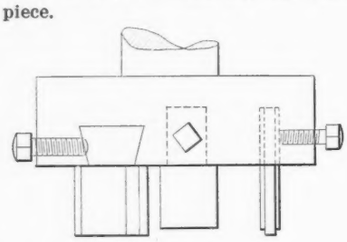


Fig. 1

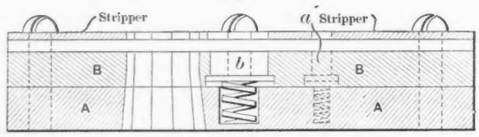


Fig. 2

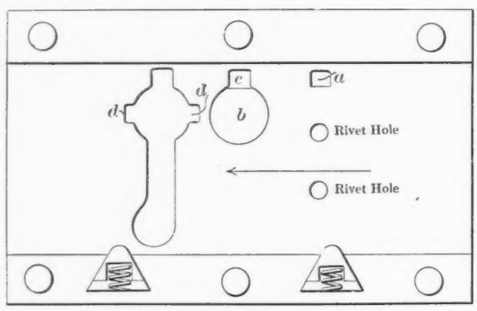


Fig. 3

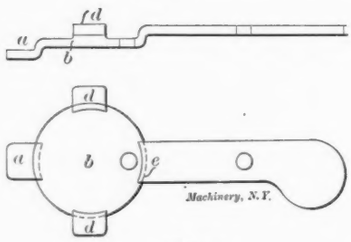


Fig. 4

Blanking and Forming Die, with Example of Work.

The first location, at the right, consists of the piercing die *f* which blanks out the point of the pawl *g* by piercing the stock immediately adjacent, as at *i*. For the next location, we place the hole *f* on the locating stud, and form the point of the pawl at *h*. The punch for this operation is longer than the rest and is rounded nicely on forming side, as shown. The next operation blanks out the pawl and drops it through the die. This die should be a trifle longer than the blank on the point so that the punch can be entered into the die at this point before cutting commences. The punch is ground as shown for this express purpose. I used a "plate" stripper on die with good results.

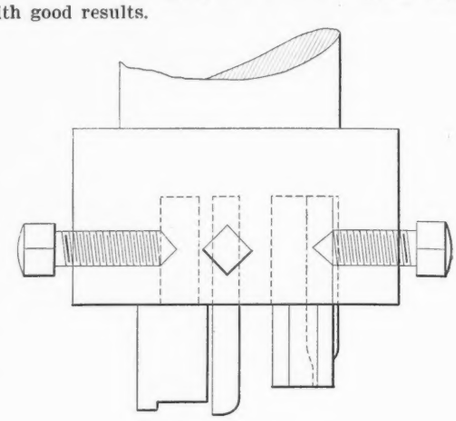


Fig. 5

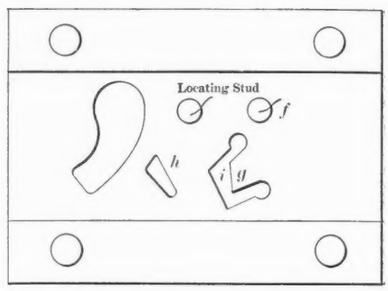


Fig. 6

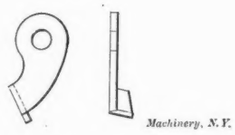


Fig. 7

Pawl and the Punch and Die used in its Manufacture.

Our work is mostly shuttles, of which we make nearly forty varieties. We now put but two operations on an average on each shuttle spring, *i e.*, blanking and forming.

Belvidere, Ill. V. H. MARCELLUS.

APPLIANCES FOR BORING, FACING AND TURNING SMALL SPUR GEARS.

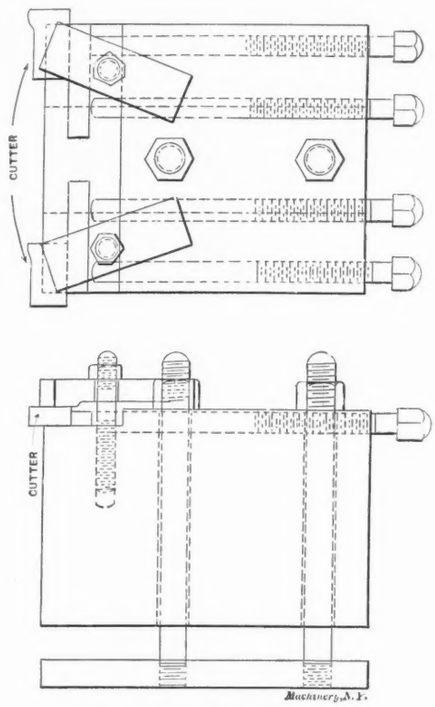
Editor MACHINERY:

Herewith are described the fixtures and methods of using the same for the rapid and accurate boring, facing and turning of spur gears of any diameter from 2 inches up to 10 or 12 inches, according to the needs of the maker. This method applies to all gears, whether solid and with a key-way; solid and without the key-way; with a web and with or without a key-way; it also applies to gears with spokes, with key-way, or without key-way. There are many manufacturers who make a large number of spur gears of the same size or rather who make a number of different sizes and a large number of each size. To those who do make a large number of spur gears of the same size, this article should be especially interesting.

We will suppose that a manufacturer is a maker of engine lathes. Of course all engine lathes are supplied with a set of change gears. To commence with the operations, begin with either the largest or smallest gear and work either from the largest to smallest or *vice versa* so to have the gears follow along according to size.

The first operation is to bore to size and face one side; this is done in an ordinary lathe chuck. For boring the gear, use a centering tool to make a hole to start the drill in; then drill the hole with a drill which is 1-64 inch smaller than the desired size; then face off the side with the tool shown in the cut.

After facing off the side, the reamer is used to get the hole to the desired size. After the whole lot of gears are bored and faced on one side the next operation is to face off the remaining side. To do this use a taper plug made to fit the spindle of the lathe with the part that projects from the spindle shorter in length 1-16 inch or more than the width of the gear when finished, and turned to fit the gear. With small gears which have a key-way, a key inserted in the plug is sufficient to drive the gear in facing the remaining side. With larger gears which have a web or spokes, a driver is used on the faceplate. A ½-inch to ⅝-inch pin made to drive in a hole in the faceplate and to bear against a spoke or a lug cast on the web is sufficient to drive the larger gears. Where there is no key-way used in the gears a hole will have to be drilled in the side of the small solid gears for the driving pin to enter to drive the gear.



Tool Block for Facing Small Gears.

For turning the outside diameter of the gears use a gang arbor capable of holding from 6 to 12 gears when faced on both sides. An ordinary nut on the end of the gang arbor will hold gears in good shape for turning, even as large in diameter as 8 to 10 inches.

The toolholder shown in the cut is to be fastened on the cross slide of lathe by the two studs and strap at the bottom. The cutters are separate, and are backed by a loose gib. The screws come against the gib for adjusting the cutter. Each cutter has a separate clamp and stud for clamping down. The cutters can be moved relatively to each other as the diameter of the gear varies. The front cutter faces the hub while the rear cutter is facing the rim. For small solid gears the front cutter alone is used.

C. J. SHAW.

BORING TAPER HOLES IN LATHE TAIL SPINDLES.

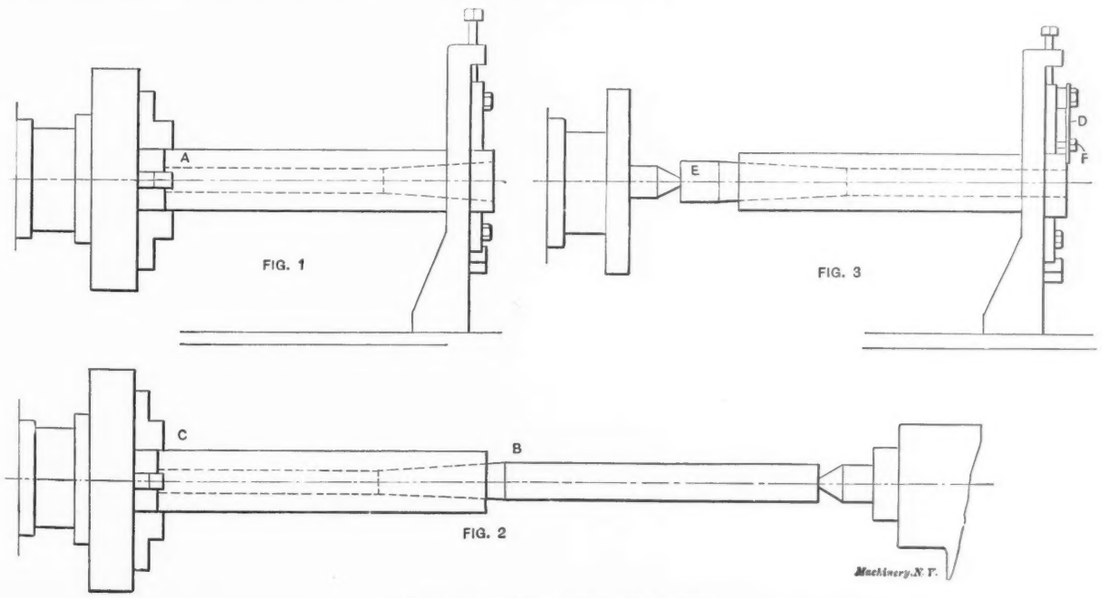
Editor MACHINERY:

The alignment of the taper hole in the tail spindle of a lathe is not as apt to be closely inspected by users as that of the head spindle, but in some cases it is very convenient to have it true. Any error is especially noticeable when using boring bars held in the tail spindle whether running in a bushing in the hollow head spindle or through a bushing in a stationary rest. For work between centers the hole may point off at quite an angle horizontally without bothering; if it is out vertically it is not noticeable unless it is quite a little out. The writer has found the following method of boring these spindles both inexpensive and accurate:

After roughing out the stock, which we take ⅛-inch larger than the finished spindle, and boring a hole clear through, the size of the small end of the center hole, we are ready for our first operation, which is indicated in Fig. 1. We hold one end in a chuck, preferably a good four-jaw independent chuck for convenience in future operations. The other end runs in the center-rest. We run in a couple of chucking drills and then a roughing reamer following up with a few turns of the finishing reamer. A floating holder for the reamer is the correct thing for this job, but if your shop does not afford this luxury a ⅜-inch nut put between the tail-center and the end of the reamer answers all purposes.

For the second operation, put in the arbor as shown in Fig. 2. Make this arbor project about a foot for small spindles and equal to the length of the spindle for larger ones. This will give a convenient length to use and the arbor will not be limber. Now shift the end in the chuck till the arbor runs true at *B*. A very few minutes will bring it true to a quarter-thousandth. When it is set, turn a spot at *C*, wide enough for the center rest jaws.

For the third operation turn the spindle around as in Fig. 3. Replace the long arbor with the short taper plug *E*. Both plug and arbor must be accurately ground as the desired results depend on their accuracy. Notice the piece of spring steel at *D* on one of the center rest jaws to hold the spindle



Boring Taper Holes in Lathe Tail Spindles.

back against the live center. This can be made heavy enough to hold a 36-inch lathe spindle and is a very easy way to rig up and is cheap. The adjustment shown is enough for most places and is a great convenience. Now go ahead and bore out the seat for the tail nut, finishing with a boring tool in the tool-post. Then put in a plug arbor in this end and finish fitting the spindle to the tail stock, on centers as usual. The results all depend on careful workmanship, but it takes no special skill to produce good results. This method would not be a good one for head spindles, as they are too long to handle in this way. An arbor long enough to indicate true running of the hole would be too limber.

In case the nut is tapped out of the solid stock, which seems to the writer to be a doubtful process, the same methods would be followed except that the first hole would not be drilled clear through, and the last operation would be the boring and tapping of the nut itself. It would probably also be well to finish turning the spindle on a larger center running on an inside chamfer of the nut instead of on an arbor.

Worcester, Mass. E. H. FISH.

SPECIAL COUNTERBORE.

W. C. Force.

Editor MACHINERY:

This counterbore was made to use in a drill-press and proved indispensable for this particular job. By placing cutter No. 2 in the bar, which is held in position by the tongue, groove and taper wedge, surface *D* was faced. By placing cutter No. 1 in the bar, hole D_1 was counterbored. In using this counterbore the drill-press was employed as in ordinary counterboring. To counterbore the under surface D_2, the drill-press spindle should run in the same direction, but instead of feeding the spindle up (which would pull the counterbore out of the spindle), it is fed with the nut *A* on the shank of the counterbore. By making the cutter No. 1 cut the surfaces *D* and D_1, it takes one operation less to do the job. In order to get the cutter No. 2 in place it is necessary to run the shank of the counterbore down through the hole in the cylinder and place the cutter into the bar through the hole in the end of the cylinder.

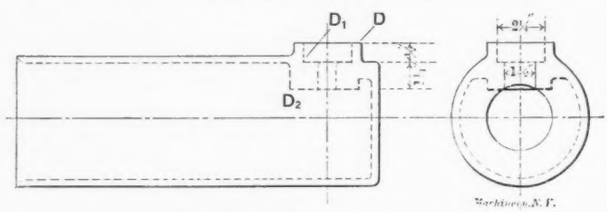


Fig. 1. The Casting to be Machined.

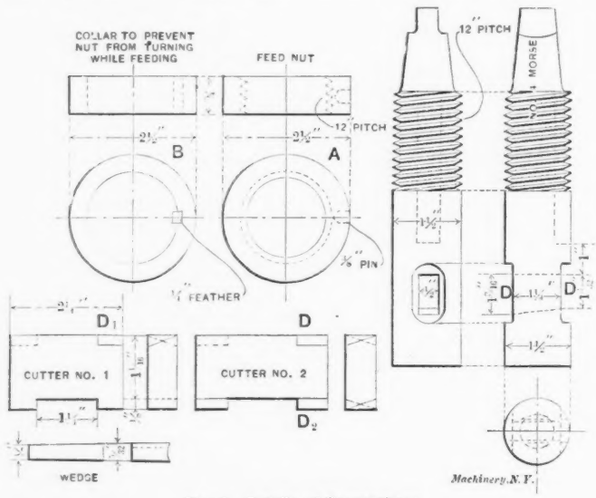


Fig. 2. Details of Counterbore.

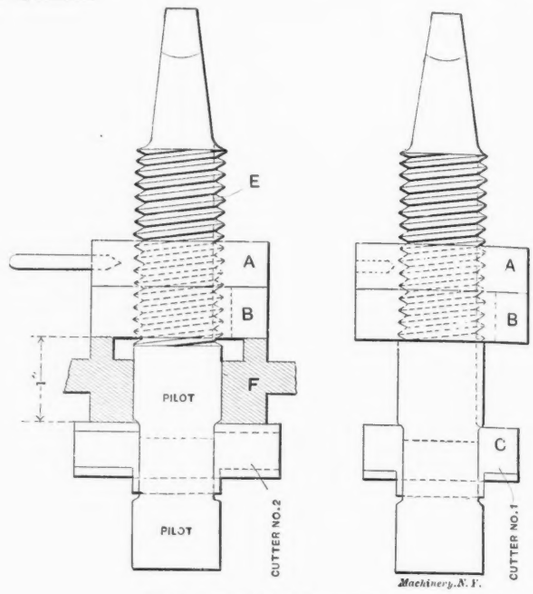


Fig. 3. Assembly of Counterbore.

By having the keyway *E* in the shank of the counterbore squared up at the end and the right distance from the cutter to equal the dimensions of the work, it is possible by feeding on the nut until it strikes the end of the slot, to get the right thickness at *F* without any measuring.

Plainfield, N. J. W. C. FORCE.

AN ELECTRICAL REPAIR JOB.

Editor MACHINERY:

This particular armature had already done lots of good work in its time and electrically speaking was in good condition. It was of the engine type, that is to say, it allowed its shaft being withdrawn without in any way interfering with the relative position of the commutator to the winding. Originally the keys had been of a badly fitting character and the spider itself must have been a bare sliding fit on the shaft instead of a press fit as is usual in such cases. As a result the armature had gradually worked loose on its shaft, which had become slightly grooved. It was decided to re-bore the spider and make a new shaft and the order was given that it was to be a shrink fit. This at first sounded rather alarming for we felt rather dubious over the shrinking part of the job, but the matter was gone into seriously and it was decided that we could make a job of it.

The first operation was to fix up the job on the table of the horizontal boring machine, and this had to be done nicely so as to allow of its being truly bored. It was set from the commutator face which had been newly turned up and from certain machine marks at the rear end of the spider. After boring, the keyways were cut which was done by sliding the bar with a cutter and opening up the old keyways to respectable dimensions. This was a very tedious job and did not allow of any taper for top fit. The spider was 18 inches internal diameter by 35 inches deep. It was chambered out 15 inches, thus leaving two sleeves 10 inches long at each end for fitting. The shaft was turned dead to standard gage with a slight lead at the nose for insertion into the hub. This shaft also had a flange against which the spider hub fitted when in place and it was necessary that it should fit tight against the face in order to allow the insertion of several bolts which played a part in the scheme. An allowance of 0.005 inch was made for shrinkage and a pin gage was made a full 1/32 inch large to gage the expansion of the hub when hot.

The armature was set up over a pit so that the shaft could be stepped vertically. By means of a cylindrical coil spirally constructed and furnished with gas and air blast the hub was made hot. The winding was carefully insulated from heat in-

WILLIAM C. FORCE was born at Plainfield, N. J., 1872. He served an apprenticeship with the Walter Scott & Co. Press Works, and is at present foreman toolmaker with the concern with which he served his time; his specialty is jigs and tools, milling fixtures and designing.

fluence by means of asbestos and in due time the eye had expanded sufficiently to allow the insertion of the pin gage. In no hurry, the hub was allowed to soak a little longer while attention was paid to the shaft which was suspended vertically from the crane ready to be lowered at the proper moment. This ready, the burner was withdrawn, the shaft left in up to the flange and arrangements immediately made for cooling off. Now the point to cool off first was undoubtedly that near the flange, for if the opposite end seized and contraction set in, then a space would be left at the flange end and an unsatisfactory job be the result. So particular attention was paid to that part, and under the influence of a judicious supply of water the job was properly cooled off and placed in the lathe for testing. We found the commutator was just 1/64 inch out of truth. JAYMAC.

CONSTRUCTION OF AN OLD COFFEE MILL.

Editor MACHINERY:

One can't put this in as something new as it is old enough to vote at least seventy-five times.* I send you this to show how little if any improvement has been made in the manufacture of coffee mills. This was bought in Germany about 1820 and had been on the market then for some time. The top *A*, body *B*, and bottom or receiver for the ground coffee *C*, are of wood in the shape of a barrel, and nicely finished. It is about 3 inches in diameter and 6 inches high. As I understand it, when a person traveled in those days, he filled the body of the mill, and when he got to an inn, procured hot water and made his coffee. As this mill is small and holds only a little coffee, they must have made very weak coffee or else the coffee bean of those days was much stronger than that we have.

Fig. 1. An Eighty-five Year Old Coffee Mill.

If you will go home and pull the coffee mill apart, you will see that the "insides" are just like this. This one seems to be made of wrought iron. Note the folding handle how it is turned down at *D* to form a stop and at *E* it is simply bent up and the wooden handle pushed over and riveted on.

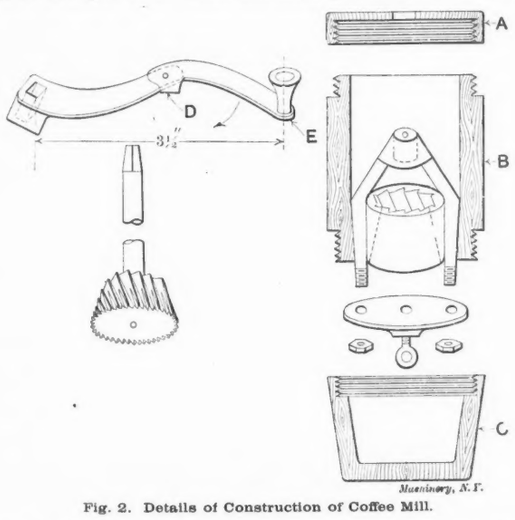


Fig. 2. Details of Construction of Coffee Mill.

New York. HERMAN JONSON.

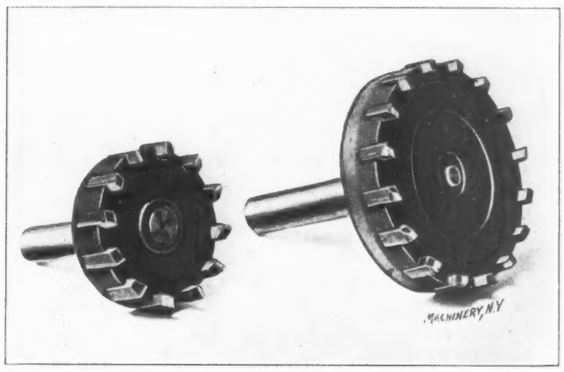
*From this we infer that a coffee mill can vote when ten years old.—EDITOR.

MILLING CUTTERS WITH TEETH CAST IN.

Editor MACHINERY:

Noticing several articles in the last few issues of MACHINERY, relative to the securing of inserted blades in milling cutters, leads me to suggest the following simple and inexpensive method which we have found very successful in our shop by actual experience.

We make a plain disk pattern of required size for the cutter head and attach to it core prints of the proper size and position for the cutters. Then the cutters, which are of self-hardening steel, are placed in the prints in the mold, just as a core would be placed. The cutters are dipped in oil before inserting in the mold as this removes all dirt and makes the cast iron adhere closely to the steel when they come together. The casting is taken from the sand as quickly as possible after pouring, to cool off in the air. We find that the casting shrinks around the steel cutters, holding them very firmly. Notches are made in the cutters to insure against their loosening.



Milling Cutter with Teeth Cast in Place.

This process softens the self-hardening steel cutters to some extent, but there is no difficulty in heating them at the forge in the ordinary way and cooling in an air-blast to get the required hardness. After this the cutting head is machined to fit the arbor and the cutters are ground to the desired shape. This is the simplest and most inexpensive method of making inserted blade mills that has come to my observation.

Such mills can be made with the cutters set in from the edge of the head so as to be surrounded by metal on end mills, or the sides of the cutters can project beyond the head sufficiently for use as a facing mill. W. L. FAY.

Dexter, Me.

DON'T USE LARD OIL ON MACHINERY.

Editor MACHINERY:

Apropos to the list of "Don'ts" as published in the June issue of MACHINERY, I would beg leave to add one more, and that is: "Don't oil up your machine with lard oil." I have seen this done so often by journeymen as well as apprentices that I have almost come to the conclusion that it is an incurable evil.

A mechanic who has any pride in his ability at all will not oil up his machine with anything else but machine oil. It is, however, the careless, hurry-up journeyman who uses lard oil; just because the machine oil can does not happen to be handy and the "Old Man" is in a hurry for the job.

I once asked an apprentice whom I found oiling up his lathe with lard oil, why he did not use machine oil? He replied that somebody had "swiped" his machine oil can; and that lard oil was just as good, and besides he could squirt it in a good deal easier.

For the benefit of any other apprentice who may be in the dark in regard to the difference between lard oil and machine oil as a lubricant I would say that lard oil should never be used in oiling up a machine of any kind, not even a lawn mower; for not only does it gum up the bearings, but its lubricating qualities are few and far between.

It may not be amiss to add in conclusion that every oil can should be marked in some manner denoting the kind of oil it contains. It is much cheaper to do this than to have the workman squirt some of the contents of the can on a bench block or on the floor in order to find out what kind of oil it is.

C. F. EMERSON.

SHOP KINKS.

A DEPARTMENT OF PRACTICAL IDEAS FOR THE SHOP.

Contributions of kinks, devices and methods of doing work are solicited for this column. Write on one side of the paper only and send sketches when necessary.

AN ADDITION TO THE B. & S. MICROMETER DEPTH GAGE

In die sinking a depth gage is an important tool. The B. & S. depth micrometer is all right for flat work but on curved work it is rather awkward. It does not give the exact depth and prevents one from seeing the point of the rod; Fig. 3 illustrates this. Figs. 1 and 2 show a simple addition which overcomes the objections and increases the tool's

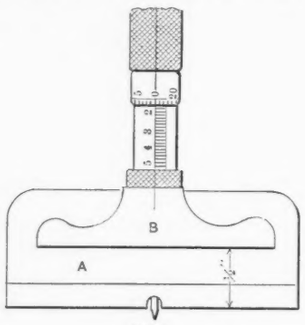


FIG.1

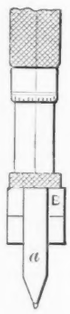


FIG.2

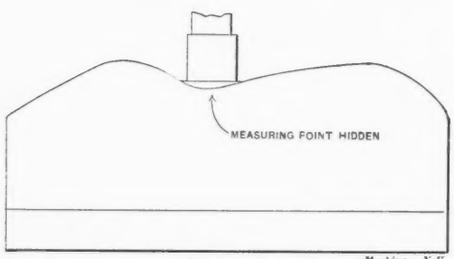


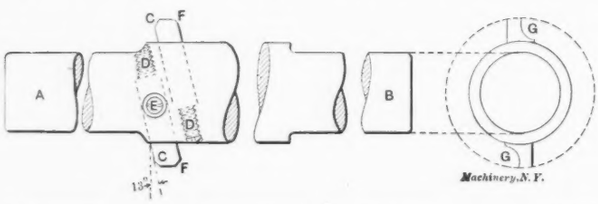
FIG.3

usefulness, especially when used on spoon and fork dies. *A* is a piece of tool steel about 5-32 inch thick, fitting snugly over the micrometer depth gage. The ½-inch dimension enables one to slip the rod down to the ½-inch groove, and read the depth direct.

C. W. SHELLY.

A FINISHING BORING BAR FOR BRONZE.

The cut shows a boring bar designed for taking a finishing cut on bronze castings in a turret lathe. The end, *A*, slides in a bushing in the hollow spindle of the lathe and the end, B, is clamped in the turret head. The angle at which the cutters are placed (on this size bar, 13 degrees) is necessarily different for every size bar, so as to keep the leading edges of the two cutters, *C*, even. The cutters are made from ½-inch round stock. They are backed up and adjusted by the screws, *D*, and fastened securely by the setscrews, *E*, which seat on



a flattened spot on the cutters. In making the cutters they are fastened in the bar, the bar put on centers in a lathe, the cutters turned to size and the leading edges, *C*, faced off, as shown. The back edges, *F*, are also faced off to give each cutter the same width of face. The top side of the front and the bottom side of the back cutter is then cut out, as shown at *G*, and the ends and leading edges, *C*, are backed off with a file. They are then ready to be removed from the bar for hardening and tempering. If it is desired to use self-hardening steel for cutters they can easily be ground between centers instead of being turned.

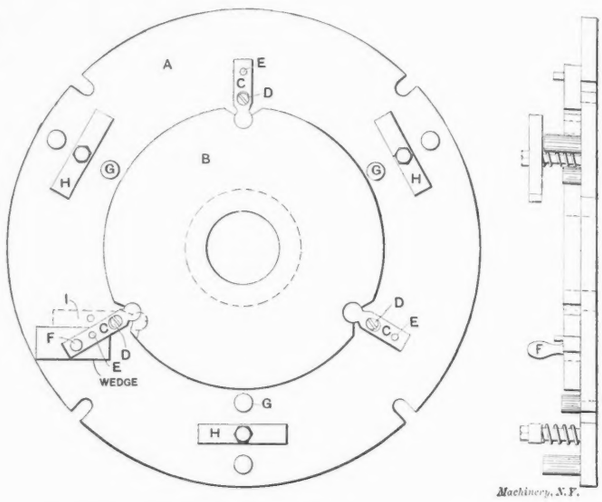
M. H. BALL.

Watervliet, N. Y.

CHUCKING FIXTURE.

The cut shows a chucking fixture for a Brown & Sharpe vertical chucking machine. This fixture might be used for chucking pulleys, gears, or any other circular work that might suggest itself.

It consists of a cast-iron plate *A* which bolts to the table of the machine. Into this plate is fitted another cast-iron plate *B* having three holes drilled and milled out to receive the levers *C*. These levers are pivoted at *D* and have a pin *E* in



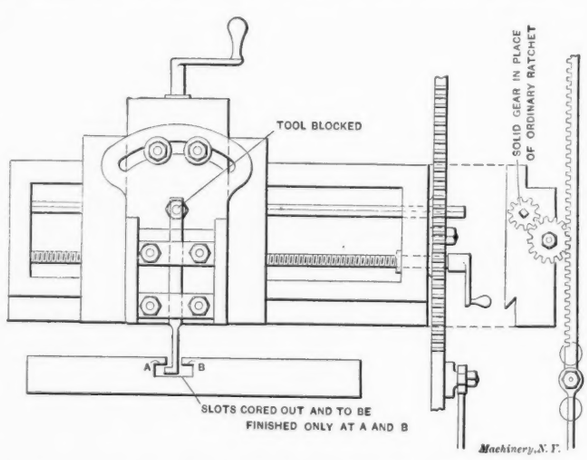
the end. One of the levers has a handle *F*, which is used to operate them. By moving this lever it causes the plate *B* to rotate, thus moving the other levers until they come in contact with the work. As they all move the same amount, it is obvious that the work will be central with the fixture. The work rests on pins *G* and is held down by straps *H*. The dotted lines at *I* show the position of the lever when in contact with the work. Also a wedge is shown between the lever and a pin to lock it in position.

P. A. R.

FEED RELIEF FOR PLANER UNDER-CUTTING TOOL.

Of course it is true that there is nothing new under the sun, but as you say in your June editorial, the old things that have been tried and proved are what we young fellows need.

I hit upon a plan to relieve an under-cutting tool on a planer when on the return stroke, which may interest some of your readers. I had a number of T-slots to cut, which were closed



at one end, so could not lift tool out on return. I blocked the hook tool solid, and put a solid gear on feed rod in place of usual ratchet. In this way you will see that the head would move up and down at every stroke. I then adjusted the feed so it would move the tool down at the end of cut and up again when back out of the way.

H. D. ELLIOTT.

Oil City, Pa.

SHOP RECEIPTS AND FORMULAS.

This page will be used for the publication of shop receipts which the contributors know from experience to be practicable. Nearly all readers of MACHINERY can add something, and it is desired that they use this page as a medium for exchanging useful formulas, thus putting them on record for the general benefit of the craft. All published receipts are paid for.

RUST JOINT.

Mix 10 parts of iron filings, 3 parts chloride of lime with enough water to make a paste. Apply this mixture to the joint, bolt firmly together and in twelve hours it will be set so that the iron will break sooner than the cement.

Detroit, Mich. DAVID MELVILLE.

TO MAKE BLACK MARKS ON GRADUATED SURFACES.

The scale is varnished over with a little thin shellac varnish, so as to sink into all the cuts. When this is dry, a black varnish of lampblack and shellac is spread on, so as to fill all the cuts. This is allowed to *thoroughly dry*. When hard, the work is driven in the lathe, and the superfluous varnish polished off with fine flour emery cloth until only that in the cuts is left. This gives a very distinct marking and fine finish to scale.

Angelica, N. Y. F. H. JACKSON.

CEMENT FOR METALS.

A very good cement that I have used for cementing metal parts consists of the following ingredients: 2½ parts zinc oxide; 1 part zinc chloride; 5 parts pulverized limestone, slag, etc. Mix to a thick paste using water. If the cement is wanted to set slowly add 1 part of zinc sulphate instead of one part of zinc chloride. The adhesive power of this cement can be increased by adding 2 per cent of ferrous sulphate to the whole. HERBERT S. GLADFELTER.

Desloge, Mo.

TO BLACKEN BRASSWORK FOR INSTRUMENTS.

To give a dull black surface to brasswork paint it with a mixture made of a thimbleful of lampblack, to which is added 4 or 5 spots of gold size. Mix well with a knife on a flat slate until the whole is about as thick as putty. Only put sufficient gold size to make the lampblack stick together, as too much will make a bright instead of a dull black. Add about twice the volume of turpentine to the mixture, stir well with a camel's-hair brush, and apply to the brasswork.

Rochester, N. Y. JOS. M. STABEL.

COPPER SOLUTION THAT WILL COLOR ON OILY STEEL.

To make a copper solution that will color on oily steel, take ½ ounce sulphate copper (blue vitriol), 4 ounces water, 1 tablespoonful oil of vitriol (commercial sulphuric acid) and dissolve the sulphate of copper in the water, then slowly add the oil of vitriol a few drops at a time, shaking well at each addition. Keep the mixture away from the face when adding the oil of vitriol; if the oil of vitriol is all poured in the bottle at once the stuff will boil and shatter the bottle, as I learned by experience. A friend of mine has a scar from an acid burn in his eye from same cause. F. W. B.

ACID HARDENING BATH.

To make an excellent hardening solution, mix pure rainwater and salt strong enough to float a raw potato, and to twenty gallons of the brine add three pints of oil of vitriol. Tool steel may be hardened at a surprisingly low heat in this solution, a very great advantage, of course, when hardening difficult shapes. The solution, however, has one slight disadvantage in that it causes the steel to rust quickly unless the steel is thoroughly scrubbed in strong hot soda water immediately after hardening. Tools hardened in this solution should come out of the bath a beautiful silver gray color, and if there are any black spots they are likely to be soft.

I. W. ANTANO.

MORTAR FOR STOPPING HOLES IN BOILER SETTINGS, ETC.

I have successfully used the following simple mortar for stopping leaks in chimneys, etc.; it is good for stopping cracks in boiler settings and other brickwork structures where not exposed to very high temperatures. Although of an improvised and primitive nature it answers the purpose very well, and has the merit of being made of materials available almost everywhere. Mix hardwood ashes, 3 quarts; chimney soot, 1 quart; common salt, 1 quart; and sufficient water to make a stiff mortar. Apply at once as it hardens quickly. This is a very old receipt; in various proportions it was used by our forefathers years ago. F. EMERSON.

Newark, N. J.

COLD TINNING PROCESS FOR USE ON FINISHED WORK IN IRON, BRASS OR STEEL.

To tin by cold process finished work in iron, brass, or steel such as pins, tacks, wire goods, etc., put twenty pounds of stock well cleaned in sawdust, in a deep pan (14 x 20 x 3 inches is a good size) having a false bottom of zinc. Heat to the boiling point a mixture of ¼ ounce of sulphuric acid and 2 ounces of tin crystals (stannous chloride) and pour over the work. Let it stand ten minutes and then stir well, using a rake, and then let it remain ten minutes longer. Repeat the process and if two coats are not enough, give it a third coat. The zinc bottom must be washed twice a day, as rusty or oily work will not tin satisfactorily.

To polish the work, put in a wooden tumbling barrel and pour in a water pail full of strong soap and water. Let it tumble fifteen or twenty minutes, according to the nature of the work, and then tumble for a few minutes in hot sawdust to dry it. J. L. LUCAS.

Bridgeport, Conn.

AMALGAM FOR STOPPING LEAKS, BLOWHOLES, ETC.

A small hole or crack that is difficult to get at or that cannot well be soldered may be closed with an amalgam composed of zinc 66 parts, tin 44 parts, and sufficient mercury to make a stiff dough. The zinc and tin are to be melted together and afterward granulated. The latter may be done by slowly pouring the melted mixture through a strong stream of water from a hose nozzle; or the filings may be used. The filings or granules are kneaded until an amalgam of the consistency of stiff dough is formed with the mercury. Excess of mercury should be squeezed out. The plastic mass is then forced into the opening and allowed to harden for an hour or two. It can then be filed and scraped like the metal itself. Only as much amalgam should be mixed as is required for immediate use.

Chicago, Ill. O. M. BECKER.

TO PRODUCE A MAT SURFACE ON STEEL.

To make a non-reflecting or mat surface on small steel articles such as screws, small steel stampings, etc., which at the same time shall be perfectly rust-proof, proceed as follows: Mix 2 ounces of powdered tartar with 20 ounces of water. Put the articles to be treated into this mixture in an earthen pot, and boil until they become yellow. Then place the articles in a tray with a solution of sulphate of copper (blue vitriol); take out when copperized and put in a tray with sulphur-ammoniac. When black, take out and rinse off with water. After the rinsing has been done carefully, mix a quantity of clean, very dry, beechwood sawdust with sufficient sweet oil, to render it slightly oily. Then thoroughly mix and rub in some powdered graphite, but only enough graphite should be added to give the whole a blackish appearance. Throw into the sawdust the steel parts to be blackened but not more at a time than about 1-3 of the quantity of the mixture. Put the whole in a small coffee-roaster such as is used in private houses, and after shaking well, roast the contents over a gentle flame, in constant motion, until the sawdust is burned to charcoal. The parts are then ready to be taken out and cooled. The roaster should be tightly closed during the roasting operation.

It is not necessary to lacquer the parts as the color put on in this manner will not wear off by ordinary handling. The parts will have a nice mat surface suitable for articles used in photographic manufacture and art goods. The formula used was a secret for many years and was successfully used by the inventor. MAX J. OCHES.

Cleveland, Ohio.

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

57. O. G.—I would like to have the following inquiry submitted in the reading columns of MACHINERY: Is there an acid which can be used for etching hardened high-speed steel?

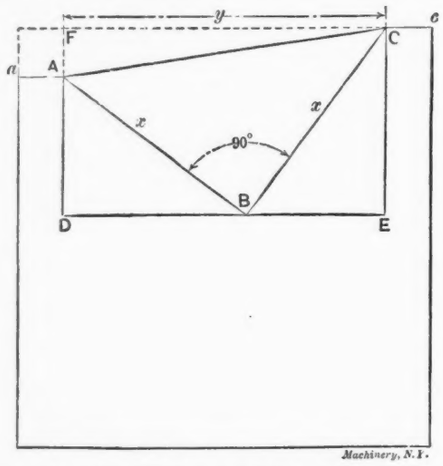
58. J. B. and P. F. L. have sent inquiries regarding the design of friction disk drives. J. B. wishes to use a driving disk 16 inches in diameter and a driven disk 12 inches in diameter, placed at right angles to the face of the driver. The driven disk is to slide on a shaft at right angles to the driving shaft to provide a variation in the ratio of the speed in their direction of rotation; and also so that the greatest power will be had at the lowest speed of the driven shaft. He would like to know the width of face to use for the driven disk when running at 900 revolutions per minute, and also what is the best friction material to employ. P. F. L. wants to know, in addition, the most efficient speed for paper or leather friction disks when running on iron disks.

A. We submit the above inquiries to our readers. Knowing, however, that the Ridgway Machine Tool Co. have recently experimented with friction disk drives for the feed mechanism of their tools, we wrote to their general superintendent, Mr. W. H. Morgan, who replies as follows: "In the writer's experience the best friction material is two leather surfaces running together. It is customary to use one leather surface and one metal surface, but we have found, in the case of our 10-16-foot boring mill, that much more power was transmitted by running two leather surfaces together. It is not practicable to run it near the center of the driving disk on account of the rotary motion obtained there, and the power also being very much less at that point for the same reason. But a comparatively small ratio of speed can be obtained through a friction drive, probably not over 2 to 1. This is due mostly to the circular motion above mentioned. We will also say that the disk which drives by its periphery should be the driver and the flat-faced disk the driven element. For one reason, if the flat disk should be the driver, and the disk that engages with it should become over-loaded and stop, it would immediately be worn flat at that point; whereas if the opposite were the case the leather disk would continue to revolve and wear itself alike all round."

Simple Solution of Question No. 55.

Editor MACHINERY:

Referring to question No. 55, in "How and Why" department, July issue of MACHINERY, I wish to offer you a simpler solution, which, I believe, comes within the scope of anyone who can read the diagram. I will make use of the same diagram that you used, so that a sketch will not be necessary.



The sum of angles CBE and ABD is 90 degrees, and so is the sum of angles CBE and BCE; hence angles BCE and ABD are equal. As triangles ABD and BCE both have a right angle and as the hypothenusæ are equal, these triangles are equal. From the above it follows that AD equals BE, so that BE is 3 inches. The rest does not need to be told.

Hamilton, Ohio. A. L. DELEEUW.

[Similar answers to question No. 55 have also been received from Mr. W. C. Searle, Worcester, Mass., Mr. W. J. Sweetser, Wellesley Hill, Mass., and Mr. E. J. Loring, Somerville, Mass. —EDITOR].

59. J. S. S.—I have made six circular forming tools for screw machine work, three of which are like that shown in the cut, and the other three are very similar. But I have not been able to harden them successfully, as they invariably crack, the cracks starting at the parts marked *A* and *B*. I used Jessop's steel, first using it forged; then cut off the bar,

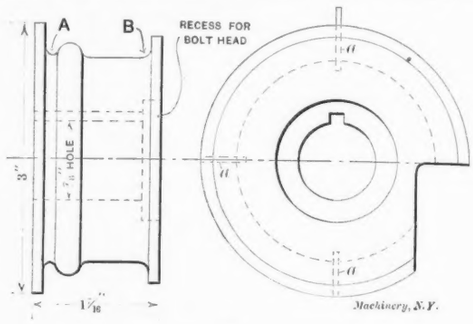


Fig. 1.

non-forged, annealing each piece three times, first, when cut off; second, when turned to within 1-16 inch of finished size; third, when finished, just previous to hardening. In all cases I was careful not to heat above a dark cherry red. Do you think I am using a steel too high in carbon? Would saw cuts as indicated at *a* prevent cracking? Following are the methods of hardening employed:

1. Heated to cherry red; dipped with cutting face up into luke-warm brine. Result: Soft spots and cracks.
2. Dipped into pail of common water with 2 inches of fish oil on surpace. Result: Blue temper and crack developed several hours afterward.
3. Dipped in cold brine. Result: Cracked.
4. Hardened the same as No. 1 and reheated. Result: Cracked in reheating; also cracked when drawing the temper in oil.
5. Hardened the same as No. 2, but did not draw temper. Result: Cracks appeared in about one-half hour.
6. Dipped into lukewarm brine, cutting face up; when cutter stopped sizzling it was plunged into cold fish oil. Result: The temper was excellent, the outside being hard and the hole soft, but it cracked as did all the others.

Answered by Mr. E. R. Markham.

In answering the above, I first wish to state that certain conditions may exist which are unknown alike to the writer and myself; for instance, the steel used may have been taken from a "piped" bar, and the attending imperfection in stock

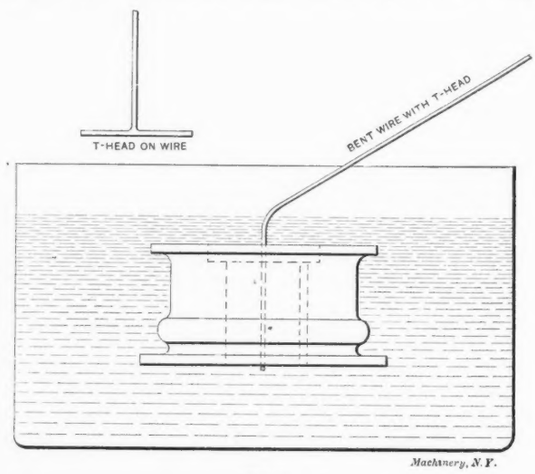


Fig. 2.

may have extended too far from the center to be entirely cut out when the 7/8-inch hole was made. This, however, is unlikely, as stock containing a pipe of any size is readily detected. Other conditions which would cause the stock to crack may exist in the fire, or the bath. As it would be useless to speculate on these, we will consider the hardening of a tool of this character under normal conditions. Jessop's steel gives general satisfaction, and probably causes as little trouble as almost any of the steels commonly used. Ordinarily as bought in the open market it contains 1.25 per cent carbon.

which is not too high for forming tools of the character shown. For several years I made forming tools of about the same diameter and thickness of steel containing 1.5 per cent carbon and experienced no trouble from cracking. Annealing after blocking out the blank somewhere near to shape is helpful if properly done, as it removes strains which are set up when the steel is drawn in the mill or forged in, in the blacksmith shop. However, in order to be effective the annealing heat must be as high as the hardening heat, but should be no higher, as high heats are injurious to the steel. It will be necessary to heat a tool having light projections very slowly, as such projections heat much more rapidly than the solid portion of the tool. The piece should be heated to a uniform *low* red; then dipped in a bath of *warm* brine. When I say warm brine I mean brine heated to a temperature of 115 to 125 degrees F. When dipped in the bath it should be placed on a piece of wire bent as shown in Fig. 2 and dipped so it can be worked around in the bath as shown, in order to bring all parts of the cutting surface into contact with the brine, thus forcing steam away from the steel and allowing the liquid to act on the entire surface and preventing soft spots. It is necessary to heat the bath considerably, as otherwise the thin portions of the cutters will harden quickly and become rigid before the balance of the cutter has stopped contracting, hence causing cracks to form. As an additional preventative I would recommend removing the cutter from the brine when it ceases to "sing," and immediately plunge into *warm* oil, working it around in the oil until it is cooled to the temperature of the oil. After it has cooled to this temperature, hold the tool over a fire, turning constantly until it is heated sufficiently to remove "strains."

If the temper needs to be drawn, and it is thought advisable to draw in a kettle of oil, do not have the oil hot when the tool is placed in it or the sudden expansion of the lighter portions will cause them to crack; place in cold or warm oil and gradually raise the temperature to the desired degree, making sure that the oil remains at the proper temperature for some time, in order that the steel may absorb the desired amount of heat, as it will not heat as rapidly as the oil. The three saw cuts indicated at *a* are employed many times to prevent cracking, and work nicely, but take away a considerable portion of the life of the tool and I have not as a rule found them necessary. If used, the cutter employed for making the slots should produce a slot rounding at the bottom, as sharp corners are an invitation for steel to crack when hardened. When a number of cutters of this character are made at a time I have found the method of hardening called "pack hardening" to give the best of satisfaction, as the tendency to crack was entirely eliminated; the cutters were much harder, and yet a great deal tougher than when hardened by any other method. This method has been described in detail in former numbers of MACHINERY.

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60. S. C. T.—We have a frame in which slides a cutter to cut tabs on index cards, such as are used in the modern card index files. The tabs are of varying widths and are located at different points on the upper edge of the card, to suit the wishes of the purchaser. Will you kindly give us a rule for locating that part of the cutter bar which cuts out the tab, the position being such as to enable us to cut the longest possible card for any given width of tab. The card may be turned over so that either side will be up when cutting, as necessary or most convenient. The only requirements are that we may cut the longest possible card and that the tab may be located at any point along the edge of the card. Sketches herewith.

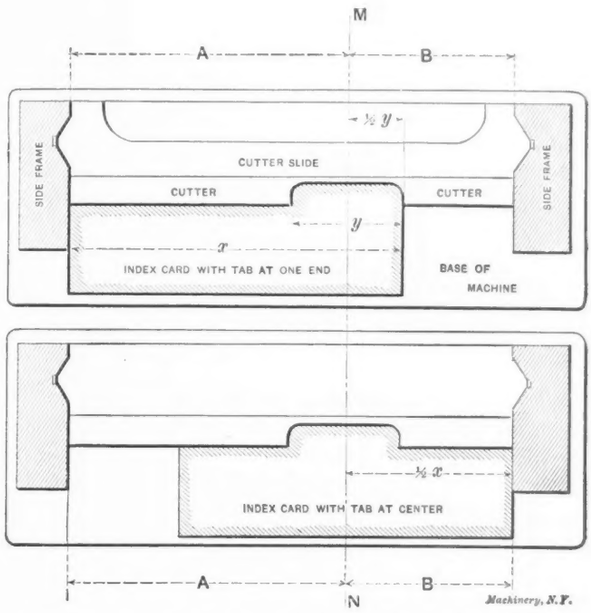
A.—An answer to this question affords a good illustration of a simple application of algebra to a practical problem. We judge that you wish to be able to locate the tab either at the center of the card or the extreme end, or at any point between these two positions. Of the two plan views of the cutting press shown herewith, the upper one illustrates the position of a card when the tab is to be cut at one end and the lower view shows the position of a card of the same size when the tab is to be at the center of the card. It is obvious that if the cutter is so located that the longest possible card can be cut in either of these two positions, any smaller size can be cut, or the long card may be so placed as to bring the tab in any intermediate position. Let $M\,N$ be the center line of the part of the knife which cuts the tab; $A + B =$ distance between frames; $x =$ length of card and $y =$ length of tab. Then, from the arrangement of the two views of the illustration it will be evident that

$$A = x - \tfrac{1}{2}\,y$$
$$B = \tfrac{1}{2}\,x.$$

Adding, we get $A + B = 1\tfrac{1}{2}\,x - \tfrac{1}{2}\,y$, which gives an expression for the distance between frames in terms of the length of card and width of tab.

Solving for x, we get

$$3/2\,x = A + B + \tfrac{1}{2}\,y$$
$$3\,x = 2(A + B) + y$$
$$x = 2/3(A + B) + 1/3\,y$$



Assume, for illustration, that the width between frames is 18 inches, and the width of tab to be cut is 1½ inches. Then, substituting in the last formula above, $x = 2/3 \times 18 + 1/3 \times 3/2 = 12\tfrac{1}{2}$ inches, for the length of card. The distance B, of the center of the recess in the knife for cutting the tab, from the side of frame, $= \tfrac{1}{2}\,x = 6\tfrac{1}{4}$ inches.

* * *

The distressful boiler explosion which occurred in a shoe factory at Brockton, Mass., March 20, 1905, and caused the death of 58 persons and injuries to 117 more, renews our attention to the danger that is practically inseparable from the lap-joint boiler seam. The boiler which exploded had a double-riveted lap-joint longitudinal seam, and a crack developed in such a way that it was hidden by the lap. It is almost impossible to discover such cracks by ordinary means of inspection as they generally start next to the lap and work outward through the sheet. The boiler which exploded was built in 1891 and had been insured by the Hartford Steam Boiler Inspection and Insurance Company during its entire life. It had been carefully inspected only three months prior to the explosion, and so far as the test showed the boiler was in good condition, but the insidious bending action, which always is present in a lap-joint seam to a greater or less degree, had cracked the shell until it had only a fraction of its initial strength. In commenting on this fatal defect of lap-joint boilers, the *Locomotive* says that the thicker the plates and the smaller the diameter of the shells, the greater is the liability of this defect developing. Although butt joints are growing in favor among boilermakers and designers it is estimated that at least 85 per cent of all the boilers now in use in the United States still have lap-joints. Hence the great danger of boiler explosions from this hidden defect in the large majority of steam boilers in use to-day. The insurance company have seriously considered the use of X-rays for detecting this hidden defect in boilers but in the present state of the art it is impracticable to use them for inspection work as the size of the apparatus necessary to generate rays strong enough to penetrate boiler plate is too great.

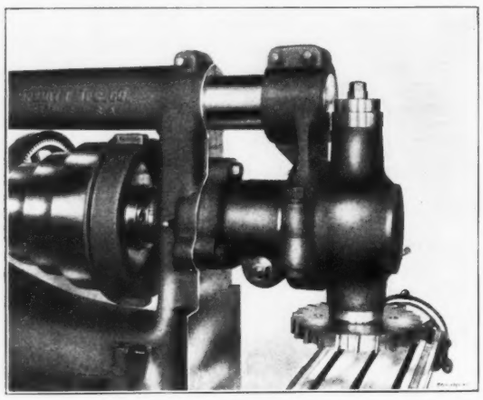
MACHINERY AND TOOLS.

A MONTHLY RECORD OF NEW APPLIANCES FOR THE SHOP.

VERTICAL MILLING ATTACHMENT.

In these days of manufacturing milling, the vertical attachment on the horizontal miller plays an important part. The cut shown below illustrates an interesting vertical milling attachment which has been brought out by the Kempsmith Mfg. Co., Milwaukee, Wis. It was designed with the idea of giving sufficient strength and rigidity to handle the same size mills and take the same heavy cuts as the main spindle of the machine. This gives in effect a vertical miller of about the same capacity as the horizontal machine to which the attachment is applied.

The vertical spindle is driven by casehardened steel bevel gears of coarse pitch, and the journals are of sufficient length to give unusually long life to the bearing and to maintain the alignment of the spindle almost indefinitely. Provision is made, however, for adjustment for any wear that may occur. The spindle has a taper hole for end mills, etc., and is threaded to take large facing cutters. Both the taper hole and the threaded nose are the same as on the main spindle, thus making all tools interchangeable. Drawbolts are furnished for drawing in and forcing out endmills, to prevent injury to the shank or teeth when changing tools.



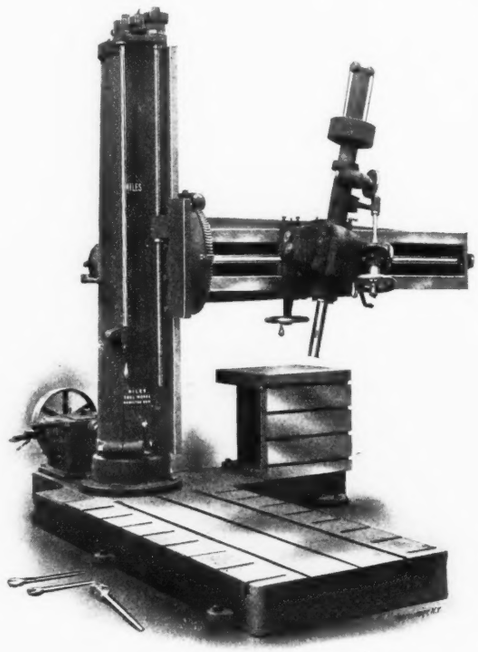
Kempsmith Vertical Milling Attachment.

The head may be swiveled clear around. All angles within the 360 degrees are indicated by graduations, and only the two bolts shown—one vertical, the other horizontal—are required to firmly secure the adjustment. Both these bolts are conveniently located. The design of the head keeps the distance from the center of the horizontal spindle to the nose of the vertical spindle very short, to permit doing work which stands unusually high from the table. The attachment is drilled to the same jig as the column of the machine for which it is intended, so it may be applied to any Kempsmith miller of certain sizes now in use. The device is built in three sizes.

NILES SIX-FOOT UNIVERSAL RADIAL DRILL.

This machine is the result of the experience of its builders with high-speed drills and it has been designed throughout to adapt it to their use. The drill head saddle fits between as well as outside of the arm guides, thus completing the double box section of the arm, insuring rigidity. The column rests on ball bearings, and the post about which it revolves extends to the extreme top of the sleeve. Steel gears, bronze bushings and ring-oiling bearings are used for all fast-running shafts.

A feature of the machine is its ease and convenience of manipulation. All feeds and speeds are changed by means of levers, carefully arranged within easy reach of the operator. Friction clutches are used for starting and stopping the machine at high speeds, reversing gears are provided for tapping, and all changes may be made even when the machine is running at its highest speed.

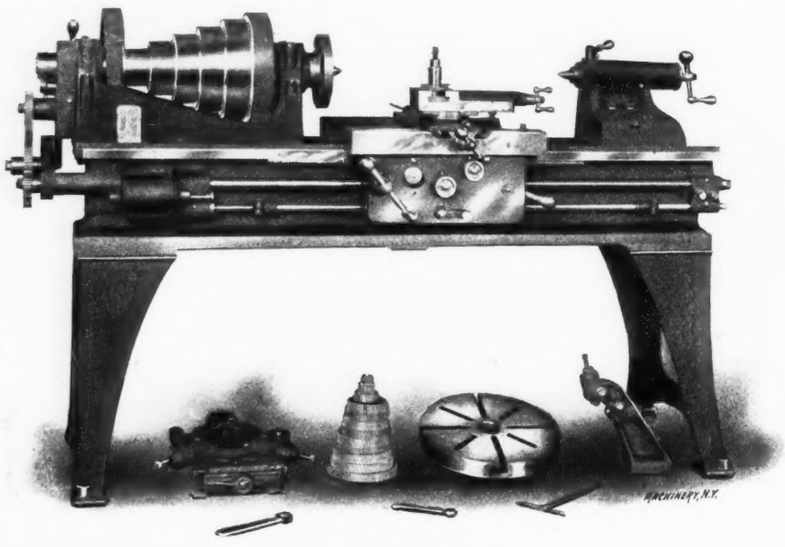


Universal Radial Drill.

This tool will drill to the center of a 12-foot circle, take 72-inch between the end of spindle and base plate, and is a full universal machine, as both the arm and the saddle can be swiveled. It is built by the Niles-Bement-Pond Co., 111 Broadway, New York.

SPRINGFIELD LATHE WITH NEW FEED REVERSE.

The Springfield Machine Tool Co., Springfield, O., are making a lathe somewhat similar in design and appearance to their "Ideal" line but incorporating new features in the feed and thread-cutting mechanism. The feed is reversed in the headstock by the clutch lever shown at the left of the index plate. This mechanism is in addition to the reverse in the



Sixteen-inch Springfield Lathe.

apron, and does away with the intermediate gear with its swinging sector, which usually has to be interposed in the change gear train when cutting a left-hand thread on lathes of this type.

The sliding rod shown on the gear box at the front gives three feeds or threads for each combination of change gears and the small handle at the top increases this number to six. The ratios of the gears in this box are so arranged as to give a suitable range of feeds for turning if the change gears are set for any ordinary thread.

The illustration shows the 16-inch size, but the lathes can be supplied in any size from 14-inch swing up to 24-inch.

QUICK CHANGE GEAR LATHE.

We show below three half-tones which give a good idea of a new feed mechanism which Flather & Co., Nashua, N. H., are putting on their standard line of engine lathes. The large cut shows it applied to the 16-inch size, but they are using it on machines running from 14-inch to to 28-inch swing.

The direction of feed is determined as usual by tumbler gears in the headstock. From here the motion is transmitted by a train of gears, which will be described later, to gear *D*, which drives shaft *A* in the feed box. This shaft is cut for a part of its length with teeth to form a long pinion and on

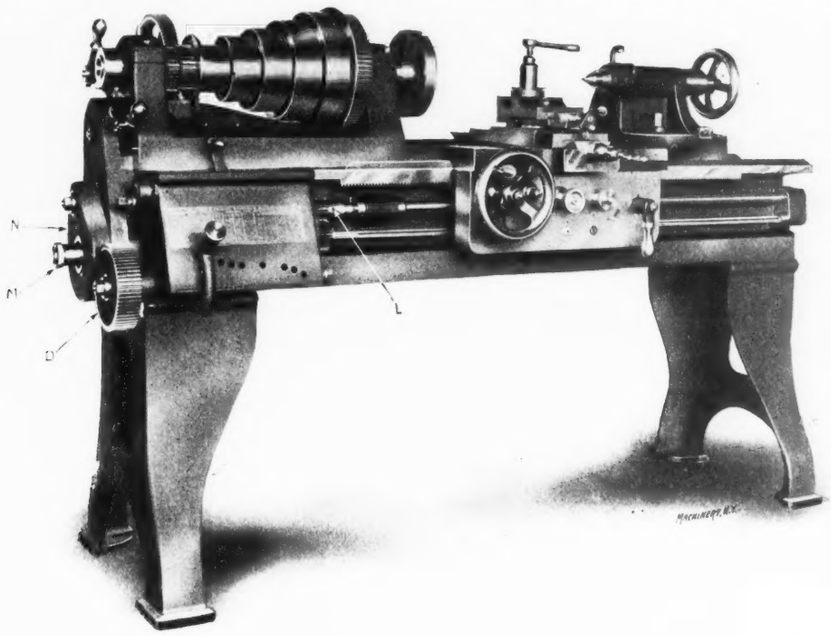


Fig. 1. Flather Lathe with Quick Change Gearing.

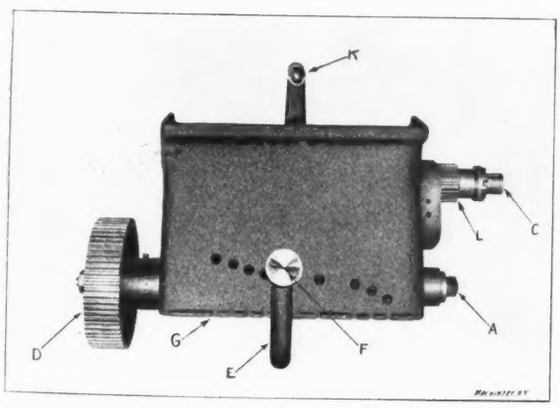


Fig. 2. Front View of Gear Box.

this portion slides the lever *E*. Shaft *B* carries the cone of gears usual in arrangements of this kind, and pivoted in lever *E*, but not shown in any of these cuts, is the usual intermediate gear, which meshes with the teeth cut in shaft *A*, and can be brought into mesh with any of the series of gears on shaft *B*. Locking pin *F* locates the lever in each of its different positions by entering into the appropriate hole drilled in the face of the gear box. *G* is a steel plate fastened to the lower edge of the box, and provided with a notch to match

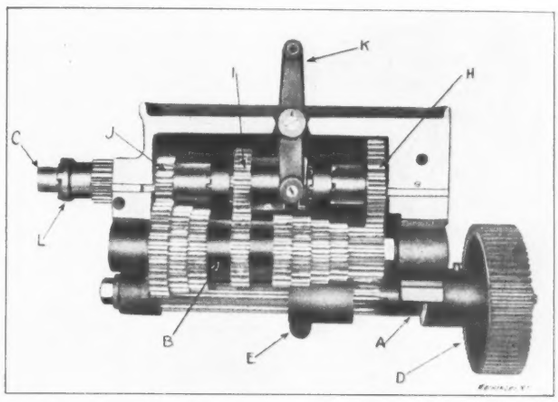


Fig. 3. Interior of Gear Box.

each locking pin hole. A projection on the inside of lever *E* enters one of these notches, and prevents the lever from being shifted along the shaft until the intermediate gear has been dropped clear of the gears on shaft *B*.

A new feature in this device is the fact that means are provided in the gear box for giving three different speeds to the feed rod or leadscrew for each position of lever *F*. Shaft *C* has turning loosely upon it two gears, *H* and *J*, whose hubs are cut to form clutch teeth. Between these two gears is a third one marked *I*, which has clutch teeth at both ends of its hub, and is splined to the shaft, but free to move endwise. An endwise movement is given to it through lever *K*, which projects through the top of the box. When in the position shown, the motion is evidently transmitted from shaft *B* to shaft *C* through gear *I* and its mating gear in the series on shaft *B*. Gear *I* may be thrown either to the right or left, and thus be disengaged from its mate, but connected by the clutch teeth on its hub with either *H* or *J*. As these are run by their corresponding drivers at different rates of speed, each position of the lever *E*, by shifting lever *K*, will give three different speeds or twenty seven in all. This is the usual way of changing the turning feeds in the shop of the manufacturer, lever *E* being located at a suitable station, the roughing and finishing feeds are obtained by lever *K*. Gear *I* has a spring pin in its hub which engages suitable depressions in shaft *C*, and thus prevents the lever *K* from being jarred out of place. Shaft *C* is extended through the gear box and carries a pinion and clutch *L*, which may be moved to the right to engage the clutch on the leadscrew, or more to the left to mesh with the gear on the feed shaft.

The 27 feeds and threads mentioned are further increased to 54 by means of a sliding gear which meshes with the wide-faced gear *D* and is moved in or out by the projecting hub seen at M. Suitable gearing in case *N* alters the ratio of rotation for these two positions. While this arrangement gives 54 feeds varying from 7 to 448 per inch, and threads from 2 to 128, the range is still further extended to permit the cutting of odd threads, metric pitches, etc., since gear *D* may be removed, and one of any suitable number of teeth inserted in its place.

Some of the novel features claimed for this lathe by the makers are extreme compactness of gear mechanism, strength, simplicity and wide range.

WESTINGHOUSE INDUCTION MOTOR.

A new type of polyphase induction motor has recently been placed on the market by the Westinghouse Electric & Manufacturing Co., Pittsburg, Pa. It is designated as type C C L. These motors are manufactured in sizes from ½ to 75 horse-power and are wound for operation on two- or three-phase circuits, at voltages of 200 and 400 for all sizes except the ½ horse-power. The sizes from ½ to 5 horse-power inclusive

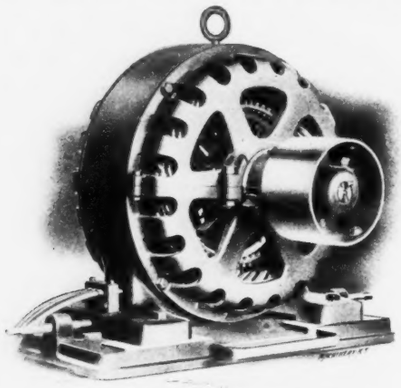


Fig. 1. Westinghouse Induction Motor.

are also wound for 100 volts. The frame of the motor is a solid cast-iron yoke. To the ends of this yoke brackets are bolted in such a way that the motor may be adapted for use on the floor, wall or ceiling. The bearings in these brackets are of ample dimensions and furnished with flooded lubrication by means of oil rings. The wear is exceedingly slight, so no provision for adjustment is made. The stationary part of the motor, which is connected to the source of current, consists of circular laminations of sheet steel securely keyed to the frame. The secondaries of these motors are of the "squirrel-cage" type, a construction which is extremely simple and durable. The winding consists of square copper bars lying in partially-closed slots and secured at the ends by screws to a ring of copper or brass large enough to dissipate the

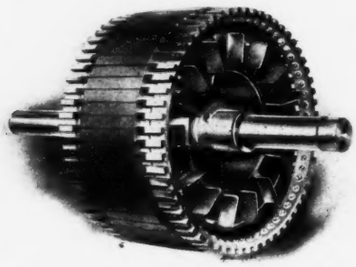


Fig. 2. Squirrel-cage Armature.

heat generated in them. The motor is designed to maintain good efficiency at low loads, so as to insure a high, all-day efficiency. Terminal leads are brought out at the base of the frame, being held in a cast-iron clip. Hand connections or knuckle joints, such as are supplied with railway motors, are used to connect the motor to the supply circuit. The cuts show the 15-horse-power size and the type of armature which is used in this line.

CUTLER-HAMMER RADIAL ARM CRANE CONTROLLER.

The illustrations herewith show a new type of crane controller, known as the radial arm, which is made by the Cutler-Hammer Mfg. Co., Milwaukee, Wis. In designing these controllers the purpose was to attain, with simple construction, proper control with the minimum number of points at which arcing could occur as the controller deteriorated in service, and to make certain that when arcing did occur it would be under pre-determined conditions and with ample protection.

In types *B* and *C* the front is mounted above the resistance, thus giving free accessibility to the connections on the back of the slate. The front itself consists of four sets of segments, the connections of which are so arranged that no reversing sector is necessary. The resistance is also arranged in four sections, each connected to its respective set of segments, making the wiring simple, and eliminating all crowding. The lever is in three pieces, insulated from each other. Before being separated this lever is cast in one piece, and all work on it is done with jigs, to insure interchangeability. The blow-out consists of a coil surrounding and embracing the controller shaft on the front of the controller, and the iron of the frame work is so disposed as to complete the magnetic circuit and give a powerful blow-out action at each of the four points at which the circuit is broken. The provision of a multiple-protected break for the circuit reduces destructive arcing to a minimum. A reliable center

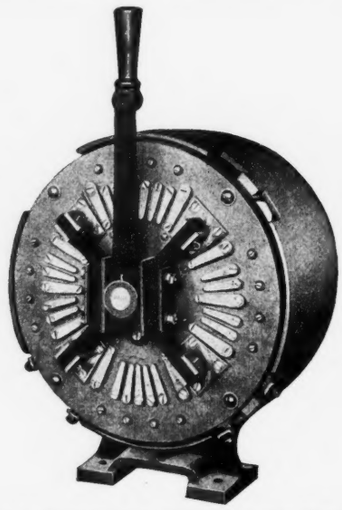


Fig. 1. Cutler-Hammer Crane Controller, Type A.

indicating device is provided, which enables the operator to feel the central or "off" position, but which will in no way prevent his reversing quickly.

The type A controller differs from the above only in the mounting of the resistance, which is of iron inclosed tube porcelain insulated construction, and is carried directly by the front. The type A controller and resistance may therefore be removed from the enclosing case and mounted directly in

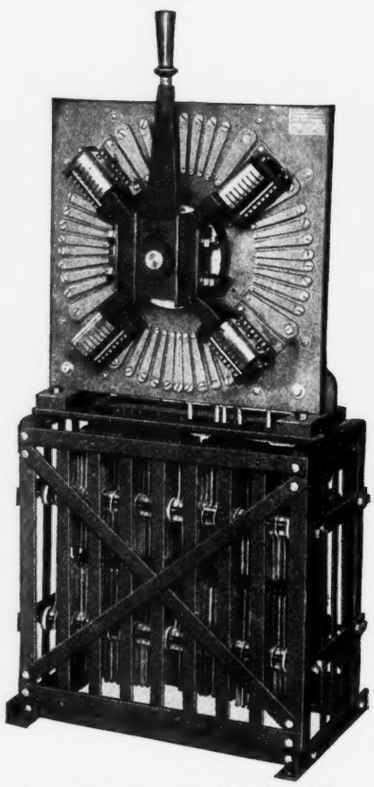


Fig. 2. Crane Controller, Types B and C.

MACHINERY'S

Draftsmen's Number

SEPTEMBER 1905 SINGLE COPIES 20 CENTS

Will be made up almost entirely of articles, charts and data of practical value to Draftsmen

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The Beam Chart

The leading feature of this number is a large folding chart equal in size to three pages of MACHINERY, containing the most complete set of formulas ever prepared for the solution of problems relating to the strength of beams. Charts of this character are usually sold only in high priced books, and this chart is alone worth more than the price of the number. As the calculation of the strength of machine parts and of structural work resolves itself into the calculation of the elementary beams of which the machine or structure is composed, the information contained in this chart is of the greatest importance. The formulas are calculated from original sources, by Sanford A. Moss, an experienced engineer in charge of the experimental research work for the steam turbine department of the General Electric Company, who is not only a practical mechanic and a technical graduate, but holds a degree of Ph.D. and has made a specialty of the mathematical side of mechanics. The beam chart he has prepared required all his spare time for a period of about nine months.

Machine Design Articles

Several leading articles in the draftsmen's number are upon machine design topics of interest to draftsmen. At the present time, when steam turbines and high-speed centrifugal pumps are being used so extensively (to say nothing of electrical machinery rotating at high speed), it is important to know how to calculate the strength of bodies rotating at high velocities. In addition to preparing the chart for this number, Mr. Moss has also contributed an article showing how to calculate the strength of high speed bodies, using approximate formulas, which greatly simplifies the process. The strength of such bodies depends upon the theory of elasticity, which has not been sufficiently proven by actual experiment to warrant the complicated formulas usually given in textbooks. Until such experimental data are at hand we believe that approximate formulas, so written as to err upon the side of safety, if at all, are of greater use than those usually given, and this article will be appreciated by draftsmen and designers.

The B. F. Sturtevant Company's Drafting-Room

The new plant of this Company contains one of the best organized drafting-rooms to be found in the country. It is thoroughly equipped with modern conveniences and the system for looking after the drawings and for supplying information to the machine shop through the drawings, lists, etc., given out by the drafting-room has been carefully developed and is a model. There will be an article upon this drafting-room and its methods, fully illustrated with a number of engravings.

Cone Pulley Design

An old problem with draftsmen and one that has been a favorite topic with textbook writers, is that of the design of cone pulleys. It was supposed long ago that the last word had been said on this subject. We have an article for the September number by a Professor at the University of Illinois, which gives an extremely simple as well as accurate and graphic solution. In looking through German literature he accidentally ran across this solution, which apparently has not been known in America; and he explains its application by using illustrative examples so that draftsmen can apply it. By its aid a pair of cone pulleys can be designed in ten minutes, that, by the usual analytical methods, would require several hours to proportion.

Spiral Gear Problems

Another practical article deals with a subject that a great deal has been written upon, and like the previous one, commends itself to the reader, because it simplifies the problem for the benefit of the student and designer. This article treats of spiral gears, and is by Professor E. H. Fish, of the Worcester Polytechnic Institute. The course at Worcester is extremely practical, treating largely of the shop end of engineering, and they have developed a system for the solution of spiral gear problems that is direct, simple and practical, and which forms the subject of the article in question.

Charts for Proportioning the parts of Machines

Several charts will be published in the body of the paper, some of them covering full pages, to assist the draftsman in proportioning the parts of machines and saving him laborious calculations. One of these is an elaborate diagram giving safe dimensions for thick cylinders to withstand high pressures. Another is upon the relative torsional strength and weight of solid and hollow shafts. This latter is an unusually complete and comprehensive table. Still another chart, which is the most complete of its kind that we have seen, is for the purpose of calculating the time for machine work at different feeds and speeds. Numerous smaller diagrams will appear, one upon proportions for machine handles, and others of equal practical value.

Short Articles

BEVEL GEAR CHARTS. By George J. Porter, Syracuse, New York. Gives simple rules for calculating all the required elements for bevel gears when mated at any angle.

GROUPING MACHINERY DATA SHEETS. By K. B. Illustrates a method of grouping data sheets in convenient form so as to have subjects of like nature together.

KINKS FOR DRAFTSMEN. By E. W. Beardsley, Waterbury, Conn. Gives some hints for instrument repairs, making celluloid templets, special scales, etc.

INSTRUCTIONS FOR DRAFTSMEN. By E. W. Beardsley, Waterbury, Conn. Gives some practical hints which are the result of years of experience in the drawing room, which should be particularly valuable to young draftsmen.

TABLE FOR SETTING PROPORTIONAL DIVIDERS. By Herman Jonson, New York.

CHECKING DRAWINGS. By Robert Grimshaw. This article takes up step by step the features of drawings which should be carefully verified.

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